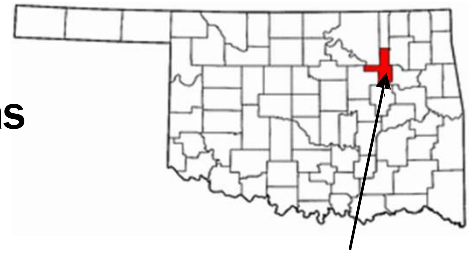
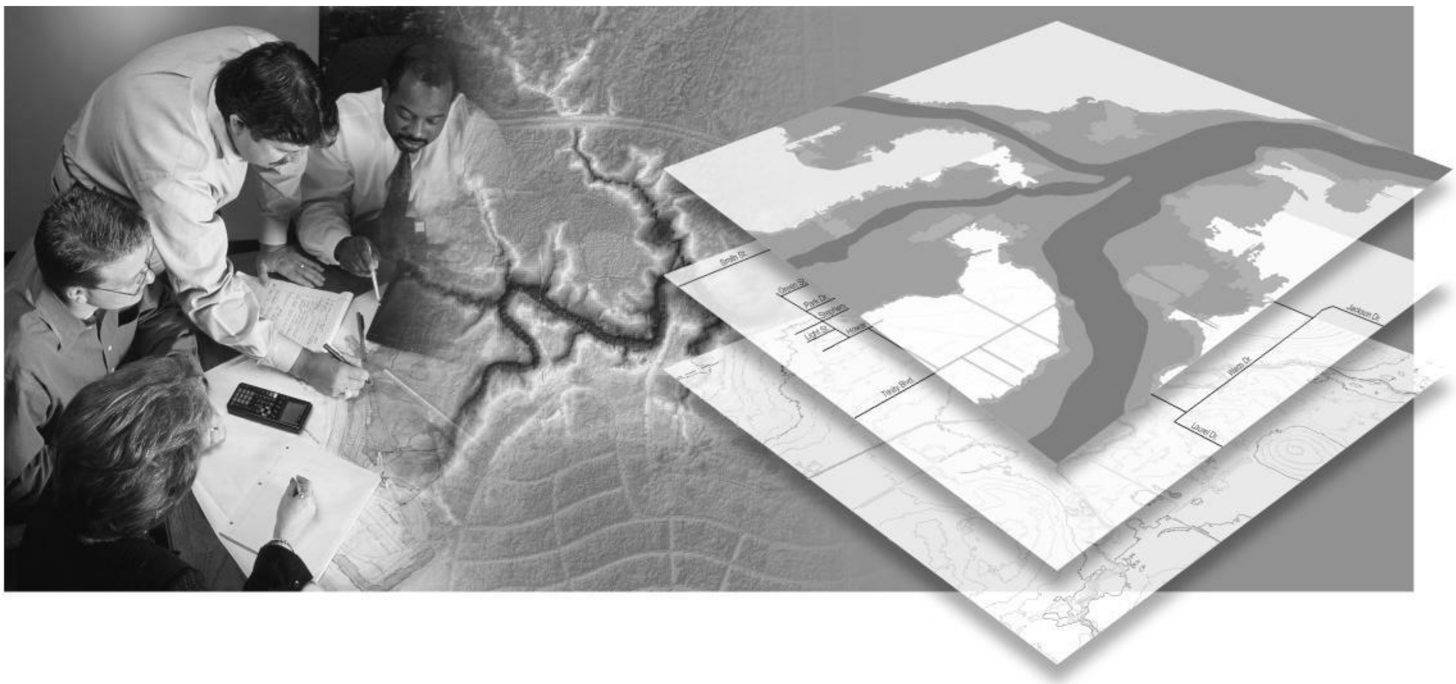
Flood Insurance Study

Tulsa County, Oklahoma and Incorporated Areas

VOLUME 1 of 8





COMMUNITY NAME	COMMUNITY NO.
Bixby, City of	400207
Broken Arrow, City of	400236
Collinsville, City of	400360
Glenpool, City of	400208
Jenks, City of	400209
Lotsee, Village of [1]	400546
Owasso, City of	400210
Sand Springs, City of	400211
Sapulpa, City of	400053
Skiatook, Town of	400212
Sperry, Town of	400213
Tulsa, City of	405381
Tulsa County (Unincorporated Areas)	400462

[1] No Special Flood Hazard Areas Identified

Revised: September 12, 2024
FLOOD INSURANCE STUDY NUMBER
40143CV001F

FEMA

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

Part or all of this Flood Insurance Study may be revised and republished at any time. In addition, part of this Flood Insurance Study may be revised by the Letter of Map Revision process, which does not involve republication or redistribution of the Flood Insurance Study. It is, therefore, the responsibility of the user to consult with community officials and to check the community repository to obtain the most current Flood Insurance Study components.

Users should refer to Section 10.0, Revision Description, for further information. Section 10.0 is intended to present the most up-to-date information for specific portions of this FIS report. Therefore, users of the FIS report should be aware that the information presented in Section 10.0 supersedes information in Section 1.0 through 9.0 of this FIS report.

Initial Countywide FIS Effective Date: September 22, 1999.

First Revised Countywide FIS Revision Date: Map revised September 7, 2001 to change base flood elevations, to change special flood hazard areas, to reflect updated topographic information, and to change floodway.

Second Revised Countywide FIS Revision Date: Map revised April 16, 2003 to update corporate limits, to change Base Flood Elevations and Special Flood Hazard Areas, to revise vertical datum, to update roads and road names, to incorporate previously issued Letters of Map Revision, and to reflect updated topographic information.

Third Revised Countywide FIS Revision Date: Map revised August 3, 2009 to update corporate limits, to change Base Flood Elevations and Special Flood Hazard Areas, to revise vertical datum, to update roads and road names, to incorporate previously issued Letters of Map Revision, and to reflect updated topographic information.

Fourth Revised Countywide FIS Revision Date: Map revised October 16, 2012 to change Special Flood Hazard Areas, to reflect updated topographic information, and to incorporate previously issued Letter of Map Revision.

Fifth Revised Countywide FIS Revision Date: Map revised September 30, 2016 to change Base Flood Elevations and Special Flood Hazard Areas, and to incorporate previously issued Letters of Map Revision.

Sixth Revised Countywide FIS Revision Date: Map revised May 2, 2019 to change Special Flood Hazard Areas to reflect new detailed modeling of Joe Creek and its tributaries and to incorporate previously issued Letters of Map Revision.

Seventh Revised Countywide FIS Revision Date: Map revised September 12, 2024 to change Special Flood Hazard Areas to reflect new detailed modeling of Brookhollow Creek and its tributaries, Haikey Creek, and Little Haikey Creek, and to incorporate a channelization project related to a newly accredited levee along Haikey Creek.

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EXHIBITS (Continued)

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VOLUME 5 (CONTINUED)
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(September 12, 2024)
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VOLUME 8
(September 12, 2024)
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FLOOD INSURANCE STUDY
TULSA COUNTY, OKLAHOMA AND INCORPORATED AREAS

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study (FIS) revises and updates information on the existence and severity of flood hazards in the geographic area of Tulsa County, Cities of Bixby, Broken Arrow, Collinsville, Glenpool, Jenks, Owasso, Sand Springs, Sapulpa, and Tulsa; the Towns of Skiatook, and Sperry; the Village of Lotsee; and the unincorporated areas of Tulsa County (referred to collectively herein as Tulsa County), and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood-risk data for various areas of the community that will be used to establish actuarial flood insurance rates and to assist the community in its efforts to promote sound floodplain management. Minimum floodplain management requirements for participation in the National Flood Insurance Program (NFIP) are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

Please note that the Cities of Bixby and Broken Arrow are geographically located in Tulsa and Wagoner Counties; the Cities of Collinsville and Owasso are geographically located in Tulsa and Rogers Counties; the City of Tulsa is geographically located in Tulsa, Osage, Rogers, and Wagoner Counties; the City of Sapulpa is geographically located in Tulsa and Creek Counties; the Town of Skiatook is geographically located in Tulsa and Osage Counties; the City of Sand Springs is geographically located in Tulsa, Osage, and Creek Counties. Only the portions of these communities located in Tulsa County are included in this FIS.

Please note that the Cherokee Nation and Muscogee Creek Nation exist within and outside of the geographical area of Tulsa County. These Tribal Nations do not have floodplain management regulation or jurisdiction within Tulsa County. Therefore, the Cherokee Nation and Muscogee Creek Nation are not included in this FIS.

Please note that on the effective date of this study, the Village of Lotsee has no mapped Special Flood Hazard Areas (SFHA). This does not preclude future determinations of SFHAs that could be necessitated by changed conditions affecting the community (i.e. annexation of new lands) of the availability of new scientific or technical data about flood hazards.

In some states or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence, and the State (or other jurisdictional agency) will be able to explain them.

The Digital Flood Insurance Rate Map (DFIRM) and FIS Report for this countywide study have been produced in digital format. Flood hazard information was converted to meet the Federal Emergency Management Agency (FEMA) DFIRM database specifications and geographic information standards and is provided in a digital format so that it can be incorporated into a local Geographic Information System and be accessed more easily by the community.

1.2 Authority and Acknowledgments

The sources of authority for this FIS report are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The 1999 countywide FIS was prepared to include incorporated communities within Tulsa County, as well as unincorporated areas, into a countywide Flood Insurance Study. Information on the authority and acknowledgments for each jurisdiction included in this countywide Flood Insurance Study, as compiled from their previously published Flood Insurance Study report narratives, is shown below. The number of the study relates to the revisions made to streams within the identified area. For example, there were four studies performed affecting streams within the Unincorporated Areas of the County. Therefore, references are made to studies one, two, three and four.

Unincorporated Areas

The hydrologic and hydraulic analyses for the first study were performed by the U.S. Army Corps of Engineers (USACE), Tulsa District, under Interagency Agreement Nos. IAA-H-7-76, Project Order No. 22, and IAA-H-10-77, Project Order No. 2, and all amendments there to. That work was completed in March 1980. The second study included the hydraulic analysis for Haikey Creek performed by the USACE, Tulsa District. That work was completed in August 1986.

The hydrologic and hydraulic analyses for Sand Creek were also in the second study and were performed by the USACE, Tulsa District, for the Federal Emergency Management Agency (FEMA), under Interagency Agreement No. EMW-90-E-3263, Project Order No. 3. That work was completed in February 1991.

The hydrologic and hydraulic analyses for Little Sand Creek in the second study were performed by the USACE, Tulsa District, for FEMA, under Interagency Agreement No. EMW-91-E-3529, Project Order No. 5. That work was completed in October1992.

The hydrologic and hydraulic analyses for Nichols and Rolling Meadows Creeks in the third study were performed by the USACE, Tulsa District under Interagency Agreement No. EMW-89-E-2994, Project Order No. 5. That work was completed in May 1990.

Information pertinent to the third study was supplied by the Tulsa Metropolitan Area Planning Commission (TMAPC), Tulsa County, the City of Tulsa, other nearby communities, and the local public.

In the third study, the hydrologic and hydraulic analyses for Horsepin Creek for its entire length within Tulsa County and along South Fork Horse Creek from its confluence with Bird Creek to the downstream side of the Southern Pacific Railroad were performed by Hydrologic, Inc., for FEMA, under Contract No. EMW-93-C-4187. This study was completed in July 1996.

In the fourth study, detailed and approximate hydrologic and hydraulic analyses were performed by Meshek and Associates, Inc. for the Cities of Bixby, Owasso, and Sand Springs; by Watershed VI Alliance, for FEMA, under Contract No. EMT-2002-CO-0048, in a study completed in November 2005; and by the USACE, Tulsa District.

The following flooding sources were studied by detailed methods by Meshek and Associates, Inc.: Bird Creek Tributary 5A, Bixby Creek, Coal Creek Tributary A, Coal Creek Tributary B, Coal Creek (West Tulsa), Euchee Creek, Fry Ditch No. 1, Fry Ditch No. 1 Tributary, Fry Ditch No. 2, Fry Ditch No. 2 Tributary, Nichols Creek, Nickel Creek, Polecat Creek, Prattville Creek, Ranch Creek Tributary A, Ranch Creek Tributary B, Rolling Meadows Creek, Sand Creek, and Shell Creek.

The following flooding sources were studied by detailed methods by Watershed VI Alliance: Blackjack Creek Tributary A, East Blackjack Creek Tributary, East Branch Haikey Creek, East Creek, Floral Haven Creek, Haikey Creek, Little Haikey Creek, Middle Branch Haikey Creek, Olive Creek, Park Grove Creek, Turtle Creek, West Branch Haikey Creek, and West Branch Haikey Creek Tributary. The hydrologic analyses for the Haikey Creek watershed were performed by the USACE, Tulsa District.

The following flooding sources were studied by detailed methods by the USACE, Tulsa District: Anderson Creek, Anderson Creek Tributary, Anderson Creek Tributary A-1, Arkansas River, Berryhill Creek, Berryhill Creek Tributary, Bigheart Creek, Bird Creek, Blackjack Creek, Charley Creek, Cherry Creek (North Tulsa), Cherry Creek Tributary, Delaware Creek, Duck Creek, Duck Creek Tributary, Elm Creek, Fisher Creek, Fisher Creek Tributary, Franklin Creek, Harlow Creek, Hominy Creek, Horsepen Creek, Horsepen Creek Tributary 1, Horsepen Creek Tributary 2, Horsepen Creek Tributary 3, Horsepen Creek Tributary B, Horsepen Creek Tributary B Tributary, Horsepen Creek Tributary C, Little Sand Creek, Panther Creek, Posey Creek, Posey Creek North Tributary 1, Posey Creek South Tributary 1, Posey Creek South Tributary 2, Ranch Creek, Ranch Creek Tributary, Shady Grove Creek, Skalall Creek, Skalall Creek Tributary, Skunk Creek, Snake Creek, Snake Creek Tributary, and White Church Creek.

Floodplain boundaries of all other streams that were previously studied by detailed methods were redelineated based on more detailed and up-to-date topographic mapping.

As part of this study, the following streams have been renamed: Arkansas River Tributary (at Bixby) is now Bixby Creek; Arkansas River Tributary (at Sand Spring) is now Franklin Creek; Bird Creek Tributary 5B is now Ranch Creek Tributary; Blackboy Creek is now Bigheart Creek; Harlow Creek Tributary is now Shady Grove Creek; North Duck Creek is now Duck Creek Tributary; Posey Creek Tributary is now Posey Creek Tributary 1; and West Blackboy Creek is now West Bigheart Creek.

City of Bixby

The hydrologic and hydraulic analyses for the first study were performed by the USACE, Tulsa District, for the Federal Insurance Administration (FIA), under Interagency Agreement Nos. IAA-H-16-75, Project Order No. 19, and IAA-H-7-76, Project Order No. 1. That work, which was completed in September 1977, covered all significant flooding sources in the City of Bixby.

City of Broken Arrow

The hydrologic and hydraulic analyses in the second study represent a revision of the original analyses performed by the USACE, Tulsa District, for FEMA, under Interagency Agreement Nos. IAA-14-7-76, Project Order No. 22, IAA-H-10-77, Project Order No. 2, and amendments thereto. The first study was completed in April 1979. The second study, also performed by the USACE, Tulsa District, for FEMA, was completed in July 1983.

The fifth study incorporates three Letters of Map Revision (LOMRs) for the City of Broken Arrow: a LOMR for Olive Creek dated February 28, 2002, and two LOMRs for Haikey

Creek and its tributaries dated September 8, 1999, and December 8, 1999. These LOMRs included changes to hydrologic and hydraulic analyses.

The hydrologic and hydraulic analyses for Broken Arrow Creek, West Branch Broken Arrow Creek, Sequoyah Creek, and Unnamed Tributary 1, 2, 3 and 4 to West Branch Broken Arrow Creek were performed through the CTP Contract No. EMT-2011-CA-0007 by the Oklahoma Water Resources Board (OWRB) and were completed in September 2014.

City of Collinsville

The hydrologic and hydraulic analyses for the first study were performed by the USACE, Tulsa District, for the FIA, under Interagency Agreement Nos. IAA-H-07-76, Project Order No. 22, IAA-H-10-77, Project Order No. 2, and all amendments thereto. That work was completed in December 1979.

City of Glenpool

The hydrologic and hydraulic analyses for the first study were performed by the USACE, Tulsa District, for FEMA, under Interagency Agreement No. IAA-H-10-77, Project Order No. 2, Amendment No. 11. That work was completed in May 1979. For the second study, the hydrologic and hydraulic analyses for Nichols and Rolling Meadows Creeks were performed by the USACE under Interagency Agreement No. EMW-89-E-2994, Project Order No. 5. That work was completed in May 1990.

City of Jenks

The hydrologic and hydraulic analyses for the first study were performed by the USACE, Tulsa District, for FEMA, under Interagency Agreement Nos. IAA-H-07-76, Project Order No.22, and IAA-H-10-77, Project Order No. 2, and all amendments thereto. That work was completed in May 1979.

The fourth study was revised on September 7, 2001 to incorporate the results of hydrologic and hydraulic analyses of Wilmott Creek from just upstream of the Jenks Levee to 91st Street, in the City of Jenks. These analyses were performed for FEMA by the USACE, Tulsa District, under Interagency Agreement No. EMW-97-IA-0154, Project Order No. 4. This study was complete in September 1998.

City of Owasso

The hydrologic and hydraulic analyses for the first study and the second study were performed by the USACE, Tulsa District, for FEMA. The hydrologic and hydraulic analyses for the first study were performed under Interagency Agreement Nos. IAA-H-07-76, Project Order No. 22, and IAA-H-10-77, Project Order No. 2, and were completed in November 1979. The hydrologic and hydraulic analyses for the second study were performed under Interagency Agreement No. EMW-89-E-2994, Project Order No. 5, and were completed in May 1990.

Town of Skiatook

The hydrologic and hydraulic analyses for the first study were performed by the USACE, Tulsa District, for the FIA, under Interagency Agreement Nos. IAA-H-7-76, Project Order No. 22, and IAA-H-10-77, Project Order No. 2, Amendment Nos. 7, 11, and 14. That work was completed in January 1979.

City of Sand Springs

The hydrologic and hydraulic analyses for the first study were performed by the USACE, Tulsa District, for FEMA, under Interagency Agreement Nos.IAA-H-07-76, Project Order No. 22, and IAA-H-10-77, Project Order No. 2. That work was completed in July 1979.
The hydrologic and hydraulic analyses for the second study were performed by the USACE, Tulsa District, for FEMA, under Interagency Agreement No. EMW-90-E-3263, Project Order No.3. That work was completed in February 1991. The hydrologic and hydraulic analyses for Berryhill Creek were taken from the previous Flood Insurance Study for the unincorporated areas of Tulsa County (Reference 1).

In the third study, the hydrologic and hydraulic analyses for Euchee Creek and Euchee Creek Tributary were performed by Meshek and Associates, Inc., and the analyses for Bigheart Creek, West Bigheart Creek, Fisher Creek, and Anderson Creek were performed by the USACE, Tulsa District, and were completed in 1991. The flood- hazard information for these streams was taken directly from the effective Flood Insurance Study report and Flood Insurance Rate Map (FIRM) for the City of Sand Springs and work maps provided by the USACE, Tulsa District.

Town of Sperry

The hydrologic and hydraulic analyses for the first study were performed by the USACE, Tulsa District, for the FIA, under Interagency Agreement Nos. IAA-H-07-76, Project Order No.22, and IAA-H-10-77, Project Order No. 2. That work was completed in November 1979.

City of Tulsa

The hydrologic and hydraulic analyses for the first study were performed by the USACE, Tulsa District, for FEMA, under Interagency Agreement Nos. IAA-H-7-76, Project Order No. 22, and IAA-H-10-77, Project Order No. 2, and all amendments thereto. That work was completed in September 1979.

The second study, completed in May 1983, involved an updated hydraulic analysis for Little Haikey Creek Tributary, and was performed by Mansur, Daubert, Strella, Inc., under agreement with FEMA.

The third study, completed in August 1984, involved a revised hydraulic analysis for Vensel Creek and was performed by Mansur, Daubert, Strella, Inc., for FEMA.

The fourth study, completed in September 1986, involved an updated floodway analysis for the Arkansas River, from River Mile (RM) 514.8 to RM 523.8, and was performed by the USACE, Tulsa District.

The fifth study, completed in August 1987, involved an updated hydraulic analysis for the Arkansas River, from RM 516.5 to RM 518.3, performed by Tanner Engineering.

The sixth study involved updated hydraulic analyses for Little Joe and North and South Fork Little Joe Creeks, were performed by Dewberry and Davis for FEMA. Work for that study was completed in December 1989.

The seventh study involved an updated hydraulic analysis for Brookhollow Creek, and was performed by the City of Tulsa Stormwater Management Division. That work was completed in April 1990.

The eighth study involved detailed hydrologic and hydraulic analyses of the following flooding sources: Alsuma, Audubon, Brookhollow, Catfish, Jones, Mill, Mingo, Southpark, and Tupelo Creeks; Brookhollow and Tupelo Creek Tributaries; and Tributary to Brookhollow Creek. The work was performed by the USACE, Tulsa District, for the City of Tulsa, and was completed in March 1993.

The ninth study involved detailed hydrologic and hydraulic analyses of the following flooding sources: Alsuma, Audubon, Brookhollow, Catfish, Cooley, Douglas, Eagle, Ford, Fulton, Jones, Little, Mill, Mingo, Quarry, Southpark, Sugar, and Tupelo Creeks; Tupelo Creek Tributary A, and Tupelo Creek Tributary C (referred to collectively herein as the Mingo Creek basin). The work was performed by the USACE, Tulsa District, for the City of Tulsa, and was completed in November 1995.

The LOMR issued for the City of Tulsa on June 3, 1999 resulted in the renaming of Vensel Creek and its tributaries. What used to be Vensel Creek Relocated is now Vensel Creek; what used to be Tributary No. 1 to Vensel Creek Relocated and/or Unnamed Tributary to Vensel Creek Relocated is now Vensel Creek Tributary H; what used to be Vensel Creek (below East 101st Street South) is now Vensel Creek South; and what used to be an Unnamed Tributary to Vensel Creek Relocated is now Vensel Creek Tributary D.

For information on subsequent revisions for countywide studies, please refer to Section 10.0, "Revision Descriptions".

1.3 Coordination

An initial Consultation Coordination Officer (CCO) meeting (also occasionally referred to as the Scoping meeting) is held with representatives of the communities, FEMA, and the study contractors to explain the nature and purpose of the FIS and to identify the streams to be studied by detailed methods. A final CCO (often referred to as the Preliminary DFIRM Community Coordination, or PDCC, meeting) is held with representatives of the communities, FEMA, and the study contractors to review the results of the study.

The USACE, Tulsa District; TMAPC; all levels of local, State, and Federal government; land developers; engineering firms; utilities; and private citizens were contacted for information pertinent to the individual Flood Insurance Studies.

During the preparation of the initial Flood Insurance Studies for the individual communities, FEMA representatives held coordination meetings with community officials, representatives of the study contractors for each study, and other interested agencies and citizens. The meetings, referred to as the initial, intermediate, and final Consultation Coordination Officer (CCO) meetings, were held at specified intervals during the preparation of the studies. The comments and issues raised at those meetings were addressed in the Flood Insurance Study for each community. The dates the meetings were held for each community are shown in Table 1, "Historical CCO Meetings." The history of the Flood Insurance Studies' coordination activities for the individual communities before this countywide study is presented below.

<u>City of Sand Springs</u>

An initial CCO meeting was held at the City of Sand Springs City Hall on May 2, 1989, and attended by representatives of FEMA; the City of Sand Springs; and the USACE, Tulsa District. Coordination with City officials and Federal, State, and regional agencies produced a variety of information pertaining to floodplain regulations, community maps, flood history, and hydrologic and hydraulic data.

Town of Skiatook

An initial CCO meeting was held on July 14, 1992, and attended by representatives of FEMA, the TMAPC, the Town of Skiatook, Tulsa County, and the study contractor. The streams to be studied and the limits of study were identified at this meeting.

The results of the study were reviewed at a final CCO meeting held on April 15, 1998, and attended by representatives of FEMA, the Town of Skiatook, Tulsa and Osage Counties, the State of Oklahoma, and numerous banks and insurance companies. All problems raised at that meeting have been addressed in this study.

Countywide

For the October 16, 2012 countywide revision, the final CCO meeting was held on February 7 11, 2011 and attended by representatives of FEMA, the communities, and the study contractors to review the results of the study update.

For the September 30, 2016 Polecat-Snake and Lower Verdigris watershed revision, an initial CCO meeting was held on February 29, 2012 and attended by representatives of FEMA, the communities, Oklahoma Water Resources Board (OWRB), and the study contractors to gather information about the current flood risk information and identify areas that needs to be restudied. The results of the study were reviewed at a final CCO meeting held on February 4, 2015.

A final CCO meeting was held on November 29, 2017 for the Polecat-Snake Physical Map Revision that included updates to Joe Creek, East Branch Joe Creek, East Branch Joe Creek Split Flow, West Branch Joe Creek, Little Joe Creek, North Fork Little Joe Creek, and South Fork Little Joe Creek. Attendees included the Oklahoma Water Resource Board, City of Tulsa's floodplain administrator and representatives, and FEMA's contractors to ensure all stakeholders were aware of the regulatory due process and the impacts associated with moving the study forward and developing final products. The City notified all affected stakeholders of pending changes to the Tulsa County Flood Insurance Study and associated flood hazard area.

For the September 12, 2024 Brookhollow Creek and Little Haikey Creek watersheds revision, an initial CCO meeting was held on June 24, 2014, and attended by representatives of FEMA, the communities, Chamber of Commerce representatives from Tulsa and Skiatook, Oklahoma Water Resources Board (OWRB), and the study contractor to gather information about the current flood risk information and identify areas that needs to be restudied.

The dates of the historical initial, intermediate, and final CCO meetings held for the communities within the boundaries of Tulsa County are shown in Table 1, "Historical CCO Meeting Dates."

Table 1: Historical CCO Meetings

Community Name	Initial CCO Meetings or Coordination Meetings	Intermediate CCO Meetings	Final CCO Meetings
Bixby, City of	August 4, 1975	February 16, 1977 and September 14, 1978	June 12, 2007
Broken Arrow, City of	August 5, 1976	April 10, 1979 and April 29, 1980	June 12, 2007
Collinsville, City of	December 2, 1975 and August 4, 1976	August 13, 1980	June 12, 2007
Glenpool, City of	August 5, 1976	March 28, 1980	June 12, 2007
Owasso, City of	December 2, 1975 and August 4, 1976	August 14, 1980	June 12, 2007
Jenks, City of	December 1, 1975 and August 5, 1976	February 20, 1980	June 12, 2007
Sand Springs, City of	December 1 and 2, 1975 and May 2, 1989	July 25, 1980	June 12, 2007
Skiatook, Town of	December 2, 1975 and August 4, 1976	March 13, 1979 July 16, 1979 July 14, 1992 and April 15, 1998	June 12, 2007
Sperry, Town of	December 2, 1975	July 25, 1980	June 12, 2007
Tulsa, City of	August 5, 1976	January 10, 1980 and June 19, 1981	June 12, 2007
Unincorporated Areas	November 25, 1975 and August 3, 1976	June 19, 1981	June 12, 2007

2.0 AREA STUDIED

2.1 Scope of Study

This FIS report covers the geographic area of Tulsa County, Oklahoma, including the incorporated communities listed in Section 1.1. The scope and methods of this study were proposed to, and agreed upon, by FEMA and Tulsa County.

The streams that were studied by detailed methods in the 2009 and 2014 study are shown in Table 2, "Streams Studied by Detailed Methods."

Fry Ditch Nos. 1 and 2 are approximately 15 feet wide in places and silted so badly that the invert is above the adjacent natural ground. The 1-percent-annual-chance discharge produces split flow on each side of the levees. Therefore, Fry Ditch Nos. 1 and 2 were studied as five drainage courses.

Previously, channel modifications and the construction of the South 77th Avenue bridge in the City of Tulsa necessitated the revision of the floodway, base flood elevations (BFEs), and flood profiles for Little Haikey Tributary. Vensel Creek, upstream of 101st Street, was relocated to flow directly into the Arkansas River. That revision created two new flooding sources: Vensel Creek Relocated changed to Vensel Creek and Tributary No. 1 changed to Vensel Creek Tributary H.

The May 1986 study along Haikey Creek incorporated an updated hydraulic analysis reflecting the completed levee project in the vicinity of the Hickory Hills subdivision. The revised analysis extended from the confluence with the Arkansas River to approximately 680 feet upstream of Garnett Road, a total distance of approximately 1.8 miles. In the May 1990 study, Nichols and Rolling Meadows Creeks were studied by detailed methods.

The City of Tulsa study incorporates the effects of several channelization projects. In the April 1990 study, Brookhollow Creek was restudied from South 121st East Avenue to 136th East Avenue. The study was performed to incorporate the effects of channel modifications completed within the Whispering Meadow and Tamarac subdivisions.

In addition, the following streams were studied by approximate method in the 2009 study:

Portions of Posey Creek and its tributaries; Aspen, Elm, Fisher, Prattville, and Sequoyah Creeks; Sand Springs Lake; several unnamed streams in the City of Sand Springs; several unnamed tributaries in the City of Glenpool; the upper portion of Cherry Creek; an unnamed tributary to Vensel Creek; several tributaries to Bird Creek; and other streams in northern Tulsa County.

Approximate analyses were used to study those areas having low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon, by FEMA and the individual communities.

In September 2014, Broken Arrow Creek watershed was restudied and the updated hydrologic and hydraulic analyses are incorporated. The streams studied in detail include Broken Arrow Creek, West Branch Broken Arrow Creek, Sequoyah Creek, Unnamed Tributaries 1, 2, 3 and 4 to West Branch Broken Arrow Creek.

For the September 30, 2016 study, Broken Arrow Creek watershed was restudied and the updated the hydrologic and hydraulic analyses are incorporated. The streams studied in detail include Broken Arrow Creek, West Branch Broken Arrow Creek, Sequoyah Creek, Spunky Creek, Spunky Creek Tributary A, Spunky Creek Tributary B, Spunky Creek Tributary B-1, Spunky Creek Tributary G, and Unnamed Tributaries 1, 2, 3 and 4 to West Branch Broken Arrow Creek.

For the May 2, 2019 revision, Joe Creek watershed (upstream of E 56th Street) was restudied and the updated hydrologic and hydraulic analyses were incorporated. The streams studied in detail in Joe Creek basin include Joe Creek (upstream of E 56th Street), East Branch Joe Creek, East Branch Joe Creek Split Flow, West Branch Joe Creek, Little Joe Creek, North Fork Little Joe Creek and South Fork Little Joe Creek.

For the September 12, 2024 revision, Brookhollow Creek, Brookhollow Creek Overflow, Brookhollow Creek Tributary, Little Haikey Creek, and Tributary to Brookhollow Creek Tributary were restudied in detail, and the updated hydrologic and hydraulic analyses incorporated.

The appropriate Letters of Map Revision within Tulsa County and Incorporated Areas have been incorporated into the revised FIRMs.

The areas studied by detailed methods were selected with priority given to all known flood hazards and areas of projected development or proposed construction. The flooding sources studied by detailed methods are presented in Table 2, “Streams Sources Studied by Detailed Methods.”

Table 2: Streams Studied by Detailed Methods			
Flooding Source	**Study Type**	**Reach Length (miles)**	**Study Area**
Adams Creek	Redelineation	1.60	From Wagoner County boundary to 75 ft downstream of S Lynn Lane Rd.
Adams Creek Tributary E	Redelineation	1.79	From confluence with Adams Creek to 230 ft upstream of E Reno St.
Alsuma Creek	Use of Existing Detailed Study*	1.17	From confluence with Mingo Creek to 62 ft upstream of E 55th St.
Anderson Creek	Use of Existing Detailed Study*	4.81	From confluence with Fisher Creek to Creek County boundary
Anderson Creek Tributary	Use of Existing Detailed Study*	1.61	From confluence with Anderson Creek to 1837 ft upstream of S 153rd Ave W.
Anderson Creek Tributary A-1	Use of Existing Detailed Study*	0.25	From confluence with Anderson Creek Tributary to 1311 ft upstream of confluence
Arkansas River	Use of Existing Detailed Study*	41.57	From Wagoner County boundary to Keystone Dam
Ator Tributary	Use of Existing Detailed Study*	0.14	From confluence with Bird Creek Tributary 5A to .06 ft upstream of E 4th St.
Audubon Creek	Use of Existing Detailed Study*	2.00	From confluence with Mingo Creek to 1551 ft upstream of E 31st St.
Bell Creek	Use of Existing Detailed Study*	1.30	From confluence with Mingo Creek to 934 ft upstream of E 41st St.
Bell Creek Tributary	Use of Existing Detailed Study*	1.31	From confluence with Bell Creek to 2064 ft upstream of E 46th Pl.
Berryhill Creek	Use of Existing Detailed Study*	3.59	From confluence with Arkansas River to 5994 ft upstream of S 65th Ave W.
Berryhill Creek Tributary	Use of Existing Detailed Study*	1.46	From confluence with Berryhill Creek to 182 ft upstream of W 41st St.
Bigheart Creek	Use of Existing Detailed Study*	1.89	From confluence with Arkansas River to Osage County boundary
Bird Creek	Use of Existing Detailed Study*	33.27	From Rogers County boundary to Osage County boundary
Bird Creek Tributary	Redelineation	1.06	From confluence with Mohawk Park Pond to 133 ft downstream of E 36th St N.
Bird Creek Tributary 5A	Use of Existing Detailed Study*	3.89	From confluence with Bird Creek to 3312 ft upstream of N 123rd Ave E.
Bixby Creek	Use of Existing Detailed Study*	3.76	From confluence with Arkansas River to 3727 ft upstream of E 151st St.
Blackjack Creek	Use of Existing Detailed Study*	9.56	From confluence with Horsepen Creek to 400 ft upstream of E 116th St N.
Blackjack Creek Tributary A	Detailed	1.47	From confluence with Blackjack Creek to 62 ft downstream of S 19th St.
Broken Arrow Creek	Detailed	11.16	From confluence with Arkansas River to Wagoner County boundary 57 ft upstream of S 193rd Ave E, and from Wagoner County boundary 39 ft downstream of S 193rd Ave E to about 4000 ft upstream of E 81st St.

Table 2. Streams Studied by Detailed Methods, Continued			
Flooding Source	**Study Type**	**Reach Length (miles)**	**Study Area**
Brookhollow Creek	Detailed	3.77	From confluence with Mingo Creek to S 145th Ave E.
Brookhollow Creek Overflow	Detailed	0.25	From upstream of E. 28th Street to upstream of Brookhollow Creek Cross Section 14,886
Brookhollow Creek Tributary	Detailed	1.73	From confluence with Brookhollow Creek to 875 ft upstream of S 129th Ave E.
Caney River	Redelineation	4.01	From Rogers County boundary 335 ft downstream of E. 166th St N to Rogers County boundary
Catfish Creek	Use of Existing Detailed Study*	1.20	From confluence with Mingo Creek to 28 ft downstream of E 61st St.
Charley Creek	Use of Existing Detailed Study*	4.79	From confluence with Bird Creek to 1034 ft upstream of N Yale Ave.
Cherry Creek (North Tulsa)	Use of Existing Detailed Study*	6.50	From confluence with Horsepen Creek to 330 ft upstream of E 126th St N.
Cherry Creek Tributary	Use of Existing Detailed Study*	1.20	From confluence with Cherry Creek (North Tulsa) to 5823 ft upstream of E 136th St N.
Cherry Creek (West Tulsa)	Use of Existing Detailed Study*	4.42	From confluence with Arkansas River to 2296 ft upstream of W 21st St.
Coal Creek (North Tulsa)	Use of Existing Detailed Study*	4.88	From confluence with Mohawk Park Pond to 129 ft downstream of E Independence St.
Coal Creek Tributary	Redelineation	0.44	From confluence with Coal Creek (North Tulsa) to 177 ft downstream of E Latimer Pl.
Coal Creek (West Tulsa)	Use of Existing Detailed Study*	7.87	From confluence with Polecat Creek to 4145 ft upstream of W 151st St.
Coal Creek Tributary A	Use of Existing Detailed Study*	0.87	From confluence with Coal Creek (West Tulsa) to 352 ft downstream of S Elwood Ave.
Coal Creek Tributary B	Use of Existing Detailed Study*	2.27	From confluence with Coal Creek (West Tulsa) to 45 ft downstream of E 131st St.
Cooley Creek	Use of Existing Detailed Study*	3.36	From confluence with Mingo Creek to 20 ft downstream of N 145th Ave E.
Cooley Creek Tributary	Redelineation	3.65	From confluence with Cooley Creek to 100 ft downstream of E 21st St.
Country Estates Tributary	Use of Existing Detailed Study*	0.85	From confluence with Blackjack Creek to 691 ft downstream of E 121st St N.
Crow Creek	Redelineation	1.86	From confluence with Arkansas River to 731 ft upstream of S Victor Ave.
Delaware Creek	Use of Existing Detailed Study*	6.34	From confluence with Bird Creek to Osage County boundary
Delaware Creek Tributary	Redelineation	1.64	From confluence with Delaware Creek to 30 ft downstream of N Trenton Ave.
Dirty Butter Creek	Redelineation	3.35	From confluence with Flat Rock Creek to 37 ft downstream of E Woodrow Pl.
Dirty Butter Creek Tributary	Redelineation	1.06	From confluence with Dirty Butter Creek to 100 ft downstream of E Apache St.
Diversion Channel (DC)	Detailed	1.43	From confluence with Arkansas River to 137 ft downstream of E 131st St.
Douglas Creek	Use of Existing Detailed Study*	1.55	From confluence with Mingo Creek to 302 ft upstream of southbound N State Highway 11.

Table 2. Streams Studied by Detailed Methods, Continued			
Flooding Source	**Study Type**	**Reach Length (miles)**	**Study Area**
Duck Creek	Use of Existing Detailed Study*	10.88	From confluence with Snake Creek to Okmulgee County boundary 7995 ft upstream of S Sheridan Rd, and from Okmulgee County boundary 7738 ft downstream of S Peoria Ave to Creek County boundary
Duck Creek Tributary	Use of Existing Detailed Study*	3.64	From confluence with Duck Creek to Creek County boundary
Eagle Creek	Use of Existing Detailed Study*	2.23	From confluence with Mingo Creek to 2884 ft upstream of E Pine St.
East Blackjack Creek Tributary	Detailed	1.39	From confluence with East Creek to 2700 ft upstream of US Highway 169 ramp
East Branch Haikey Creek	Detailed	5.68	From confluence with Haikey Creek to 338 ft downstream of S 3rd St.
East Branch Joe Creek	Detailed	1.98	From confluence with West Branch Joe Creek to 435 ft upstream of E 36th St.
East Branch Joe Creek Split Flow	Detailed	0.30	From confluence with West Branch Joe Creek.
East Creek	Detailed	1.67	From Rogers County boundary to Osage County boundary 2799 ft downstream of E 146th St N to confluence of East Blackjack Creek Tributary
East Creek	Redelineation	2.05	From confluence of East Blackjack Creek Tributary to E 126th St N.
Elm Creek	Use of Existing Detailed Study*	3.30	From confluence with Bird Creek to 3164 ft upstream of E 78th St N.
Euchee Creek	Use of Existing Detailed Study*	2.26	From confluence with Arkansas River to Osage County boundary
Euchee Creek Tributary 1	Use of Existing Detailed Study*	0.03	From confluence with Euchee Creek to 50 ft downstream of Willow St.
Euchee Creek Tributary 2	Use of Existing Detailed Study*	0.23	From confluence with Euchee Creek to 1208 ft upstream of confluence
Fisher Creek	Use of Existing Detailed Study*	8.00	From confluence with Arkansas River to 1824 ft downstream of S 165th Ave W.
Fisher Creek Overflow	Use of Existing Detailed Study*	1.80	From confluence with Arkansas River to 2619 ft upstream of S 145th Ave W.
Fisher Creek Tributary	Use of Existing Detailed Study*	1.89	From confluence with Fisher Creek to 1219 ft upstream of S 157th Ave W.
Flat Rock Creek	Redelineation	6.95	From confluence with Bird Creek to Osage County boundary
Flat Rock Creek Tributary A	Redelineation	1.34	From confluence with Flat Rock Creek to 413 ft downstream of Mohawk Blvd.
Flood Relief Channel (FRC)	Detailed	1.04	From confluence with Diversion Creek (DC) to 2605 ft downstream of E 131st St.
Floral Haven Creek	Detailed	2.23	From confluence with Haikey Creek to 94 ft downstream of N Aspen Ave.
Ford Creek	Use of Existing Detailed Study*	2.69	From confluence with Mingo Creek to 134 ft upstream of E 51st St.

Table 2. Streams Studied by Detailed Methods, Continued			
Flooding Source	**Study Type**	**Reach Length (miles)**	**Study Area**
Fox Meadow Tributary	Use of Existing Detailed Study*	0.44	From confluence with Blackjack Creek to 1406 ft upstream of E 120th St N.
Franklin Creek	Use of Existing Detailed Study*	3.22	From confluence with Arkansas River to Osage County boundary
Fred Creek	Redelineation	3.16	From confluence with Arkansas River to 617 ft upstream of E 71st St.
Fry Ditch No. 1	Use of Existing Detailed Study*	3.34	From confluence with Fry Ditch No. 2 to 1813 ft upstream of E 111th St.
Fry Ditch No. 1 Tributary	Use of Existing Detailed Study*	0.85	From confluence with Fry Ditch No. 1 to 620 ft upstream of E 119th St.
Fry Ditch No. 2	Use of Existing Detailed Study*	6.80	From confluence with Arkansas River to 522 ft upstream of E 86th St.
Fry Ditch No. 2 Tributary	Use of Existing Detailed Study*	0.18	From confluence with Fry Ditch No. 2 to 59 ft downstream of E Greens Ave.
Fulton Creek	Use of Existing Detailed Study*	1.06	From confluence with Bell Creek to 37 ft downstream of US Highway 64 / State Highway 51
Hager Creek	Redelineation	3.92	From confluence with Polecat Creek to 5692 ft upstream of S Elwood Ave.
Haikey Creek	Use of Existing Detailed Study*	6.81	From confluence with Arkansas River to 435 ft upstream of E 111th St.
Haikey Creek	Redelineation	0.56	From 435 ft upstream of E 111th St. to 2966ft upstream of E 111th St.
Haikey Creek	Detailed	2.31	From 2966ft upstream of E 111th St. to 271 ft downstream of E State Highway 51
Harlow Creek	Use of Existing Detailed Study*	1.61	From confluence with Bigheart Creek to Osage County boundary
Hominy Creek	Use of Existing Detailed Study*	5.21	From confluence with Bird Creek to Osage County boundary
Horsepen Creek	Use of Existing Detailed Study*	10.98	From Rogers County boundary to 2468 ft upstream of N Sheridan Rd.
Horsepen Creek North Tributary 1	Use of Existing Detailed Study*	1.88	From confluence with Horsepen Creek to 1630 ft upstream of N Memorial Dr.
Horsepen Creek North Tributary 2	Use of Existing Detailed Study*	2.57	From confluence with Horsepen Creek to 8012 ft upstream of E 166th St N.
Horsepen Creek North Tributary 3	Use of Existing Detailed Study*	2.01	From confluence with Horsepen Creek to 5260 ft downstream of N US Highway 75
Horsepen Tributary B	Use of Existing Detailed Study*	0.28	From confluence with Horsepen Creek to 368 ft upstream of confluence of Horsepen Creek Tributary B Tributary
Horsepen Tributary B Tributary	Use of Existing Detailed Study*	0.59	From confluence with Horsepen Creek Tributary B to 3110 ft upstream of confluence
Horsepen Tributary C	Use of Existing Detailed Study*	0.61	From confluence with Horsepen Creek to 718 ft upstream of E State Highway 20

Table 2. Streams Studied by Detailed Methods, Continued			
Flooding Source	**Study Type**	**Reach Length (miles)**	**Study Area**
Horsepin Creek	Use of Existing Detailed Study*	1.47	From confluence with South Fork Horse Creek to Osage County boundary, 1,090 ft downstream along sage County boundary.
Interior Drainage	Detailed	0.51	From confluence with Diversion Creek (DC) to 2677 ft upstream of confluence
Joe Creek	Redelineation	3.73	From confluence with Arkansas River to confluence of East Branch Joe Creek and West Branch Joe Creek 127 ft upstream of E Skelly Dr.
Jones Creek	Use of Existing Detailed Study*	1.74	From confluence with Mill Creek to 214 ft upstream of S 68th Pl E.
Little Creek	Use of Existing Detailed Study*	1.81	From confluence with Mingo Creek to 213 ft upstream of N 129th Ave E.
Little Haikey Creek	Detailed	7.55	From confluence with Haikey Creek to downstream of E 76th St.
Little Haikey Creek Tributary	Detailed	0.48	From confluence with Little Haikey Creek to 22 ft upstream of S 72nd Ave E.
Little Joe Creek	Detailed	2.58	From confluence with Joe Creek to S Sheridan Rd.
Little Sand Creek	Use of Existing Detailed Study*	1.85	From confluence with Arkansas River to Osage County boundary
Lower Fred Creek	Redelineation	0.75	From confluence with Arkansas River to 324 ft upstream of E 86th St.
Middle Branch Haikey Creek	Detailed	4.24	From confluence with East Branch Haikey Creek to 47 ft downstream of W Kenosha St.
Mill Creek	Use of Existing Detailed Study*	3.40	From confluence with Mingo Creek to 157 ft upstream of E 15th St.
Mingo Creek	Use of Existing Detailed Study*	16.17	From confluence with Bird Creek to 71 ft downstream of S Memorial Dr.
Mooser Creek	Redelineation	3.38	From confluence with Arkansas River to 314 ft downstream of W 57th St.
Mooser Creek Tributary	Redelineation	1.11	From confluence with Mooser Creek to 138 ft downstream of W 61st St.
Nichols Creek	Use of Existing Detailed Study*	1.59	From confluence with Coal Creek (West Tulsa) to Creek County boundary
Nickel Creek	Use of Existing Detailed Study*	2.42	From confluence with Polecat Creek to Creek County boundary
North Fork Little Joe Creek	Detailed	0.65	From confluence with Little Joe Creek to E 51st St.
Old Joe Tributary to Fred Creek	Redelineation	0.65	From confluence with Fred Creek to 2676 ft upstream of E 78th St.
Olive Creek	Detailed	2.03	From confluence with Haikey Creek to 126 ft upstream of N Elder Ave.
Panther Creek	Use of Existing Detailed Study*	2.30	From confluence with Charley Creek to 2370 ft upstream of N Yale Ave.
Park Grove Creek	Detailed	1.57	From confluence with Middle Branch Haikey Creek to 66 ft downstream of N Elm Pl.

Table 2. Streams Studied by Detailed Methods, Continued			
Flooding Source	**Study Type**	**Reach Length (miles)**	**Study Area**
Polecat Creek	Use of Existing Detailed Study*	8.39	From confluence with Arkansas River to Creek County boundary
Posey Creek	Use of Existing Detailed Study*	8.89	From confluence with Arkansas River to 52 ft upstream of E 151st St.
Posey Creek North Tributary 1	Use of Existing Detailed Study*	3.13	From confluence with Posey Creek to 134 ft downstream of S 7th St.
Posey Creek South Tributary 1	Use of Existing Detailed Study*	2.15	From confluence with Posey Creek to 2934 ft upstream of E 151st St.
Posey Creek South Tributary 2	Use of Existing Detailed Study*	2.64	From confluence with Posey Creek to 528 ft upstream of S Harvard Ave.
Prattville Creek	Use of Existing Detailed Study*	2.84	From confluence with Arkansas River to 940 ft upstream of S 112th Ave W.
Prattville Creek Tributary 1	Use of Existing Detailed Study*	0.15	From confluence with Prattville Creek to 781 ft uptsream of confluence
Prattville Creek Tributary 2	Use of Existing Detailed Study*	0.09	From confluence with Prattville Creek to 261 ft downstream of S Whispering Creek Dr.
Prattville Creek Tributary 3	Use of Existing Detailed Study*	0.25	From confluence with Prattville Creek to 1333 feet downstream of S Linwood Dr.
Prattville Creek Tributary 4	Use of Existing Detailed Study*	0.05	From confluence with Prattvilee Creek to 257 ft upstream of confluence
Quarry Creek	Use of Existing Detailed Study*	3.14	From confluence with Mingo Creek to N 145th Ave E.
Ranch Creek	Use of Existing Detailed Study*	7.90	From confluence with Bird Creek to 1088 ft upstream of E 116th St N.
Ranch Creek Tributary	Use of Existing Detailed Study*	6.65	From confluence with Ranch Creek to 1108 ft upstream of N Sheridan Rd.
Ranch Creek Tributary A	Use of Existing Detailed Study*	1.92	From confluence with Ranch Creek to 17 ft downstream of N 113th Ave E.
Ranch Creek Tributary B	Use of Existing Detailed Study*	2.08	From confluence with Ranch Creek to 55 ft downstream of E 106th St N.
Red Fork Creek	Redelineation	0.68	From confluence with Cherry Creek (West Tulsa) to 283 ft upstream of S Zenith Ave.
Redfork Creek	Use of Existing Detailed Study*	0.63	From confluence with Arkansas River to 1697 ft upstream of E 41st St.
Redfork Creek Tributary 1	Use of Existing Detailed Study*	0.28	From confluence with Redfork Creek to 1491 ft upstream of confluence
Redfork Creek Tributary 2	Use of Existing Detailed Study*	0.16	From confluence with Redfork Creek to 835 ft upstream of confluence
Remington Tributary	Use of Existing Detailed Study*	0.26	From confluence with Blackjack Creek to 240 ft downstream of E 122nd St N.

Table 2. Streams Studied by Detailed Methods, Continued			
Flooding Source	**Study Type**	**Reach Length (miles)**	**Study Area**
Rolling Meadows Creek	Use of Existing Detailed Study*	1.08	From confluence with Coal Creek (West Tulsa) to 1484 ft upstream of s 26th Ave W.
Sand Creek	Redelineation	1.74	From confluence with Arkansas River to Osage County boundary
Sand Springs Lake Tributary	Use of Existing Detailed Study*	1.88	From confluence with West Bigheart Creek to Osage County boundary
Sawgrass Tributary	Use of Existing Detailed Study*	0.16	From confluence with Ranch Creek Tributary B to 826 ft upstream of confluence
Sequoyah Creek	Detailed	1.15	From confluence with West Branch Broken Arrow Creek to about 300 ft upstream of S Ash Ct
Shady Grove Creek	Use of Existing Detailed Study*	0.69	From confluence with Harlow Creek to Osage County boundary
Shell Creek	Use of Existing Detailed Study*	0.90	From confluence with Arkansas River to Osage County boundary
Skalall Creek	Use of Existing Detailed Study*	3.87	From confluence with Bird Creek to Washington County boundary
Skalall Creek Tributary	Use of Existing Detailed Study*	2.54	From confluence with Skallal Creek to 1810 ft downstream of N Lewis Ave.
Skunk Creek	Use of Existing Detailed Study*	3.75	From confluence with Bird Creek to 1455 ft upstream of N Lewis Ave.
Snake Creek	Use of Existing Detailed Study*	11.59	From confluence with Arkansas River to Okmulgee County boundary
Snake Creek Tributary	Use of Existing Detailed Study*	3.37	From confluence with Snake Creek to 1381 ft upstream of E 181st St.
South Fork Horse Creek	Redelineation	0.85	From confluence with Bird Creek to Osage County boundary
South Fork Joe Creek	Redelineation	1.57	From confluence with Joe Creek to 43 ft downstream of E 61st St.
South Fork Little Joe Creek	Detailed	0.91	From confluence with Little Joe Creek to 176 ft downstream of S Hudson Ave.
Southpark Creek	Use of Existing Detailed Study*	2.12	From confluence with Mingo Creek to 91 ft downstream of S 129th E Ave
Spunky Creek	Redelineation	0.92	From Wagoner County boundary to 866 ft downstream of E 41st St.
Spunky Creek Tributary A	Redelineation	0.96	From Wagoner County boundary to 5070 ft upstream of S 193rd E Ave
Spunky Creek Tributary B	Redelineation	2.11	From Wagoner County boundary to 600 ft upstream of S 173rd E. Ave
Spunky Creek Tributary B-1	Redelineation	1.69	From confluence with Spunky Creek Tributary B to 658 ft downstream of S Lynn Lane Rd.
Spunky Creek Tributary G	Redelineation	0.15	From confluence with Spunky Creek to 630 ft upstream of S 193rd E Ave
Three Lakes Tributary	Use of Existing Detailed Study*	0.12	From confluence with Bird Creek Tributary 5A to 306 ft downstream of E 83rd St N.

Table 2. Streams Studied by Detailed Methods, Continued			
Flooding Source	**Study Type**	**Reach Length**	**Study Area**
Tributary to Brookhollow Creek Tributary	Detailed	0.85	From confluence with Brookhollow Creek Tributary to 342 ft downstream of S 136th Ave E.
Tupelo Creek	Use of Existing Detailed Study*	2.63	From confluence with Mingo Creek to 84 ft downstream of # 21st St.
Tupelo Creek Tributary A	Use of Existing Detailed Study*	1.07	From confluence with Tupelo Creek to 60 ft downstream of S 129th Ave E.
Tupelo Creek Tributary C	Use of Existing Detailed Study*	1.25	From confluence with Tupelo Creek to 51 ft downstream of S 129th Ave E.
Turtle Creek	Detailed	1.41	From confluence with Middle Branch Haikey Creek to 1511 ft upstream of S Lions Ave.
Unnamed Tributary 1 to West Branch Broken Arrow Creek	Detailed	0.43	From confluence with West Branch Broken Arrow Creek to about 150 ft downstream of S. Ash Ave.
Unnamed Tributary 2 to West Branch Broken Arrow Creek	Detailed	1.01	From confluence with West Branch Broken Arrow Creek to about 2300 ft upstream of S. 177th E. Ave.
Unnamed Tributary 3 to West Branch Broken Arrow Creek	Detailed	0.53	About 1650 ft upstream of confluence with West Branch Broken Arrow Creek.
Unnamed Tributary 4 to West Branch Broken Arrow Creek	Detailed	0.65	From confluence with West Branch Broken Arrow Creek to about 1250 ft upstream of E. Toledo St.
Valley View Creek	Redelineation	1.75	From confluence with Flat Rock Creek to 69 ft downstream of E 56th St N
Vensel Creek	Redelineation	2.99	From confluence with Arkansas River to 49 ft downstream of E 82nd St.
Vensel Creek South	Redelineation	1.31	From confluence with Arkansas River to 39 ft downstream of E 101st St.
Vensel Creek Tributary D	Redelineation	0.30	From confluence with Vensel Creek to 15 ft downstream of E 101st St.
Vensel Creek Tributary H	Redelineation	0.39	From confluence with Vensel Creek to 1800 ft upstream of E Creek Turnpike
West Bigheart Creek	Use of Existing Detailed Study*	2.69	From confluence with Bigheart Creek to Osage County boundary
West Branch Broken Arrow Creek	Detailed	7.57	From confluence with Broken Arrow Creek to 2400 ft downstream of E 91st St. S.
West Branch Haikey Creek	Detailed	2.54	From confluence with Haikey Creek to 32 ft downstream of S Mingo Rd.
West Branch Haikey Creek Tributary	Detailed	0.71	From confluence with West Branch Haikey Creek to 604 ft downstream from W Elgin St.
West Branch Joe Creek	Detailed	2.47	From confluence with Joe Creek to E 28th St.
White Church Creek	Use of Existing Detailed Study*	4.05	From confluence with Haikey Creek to 218 ft upstream of E 111th St.
Wilmott Creek	Redelineation	4.05	From confluence with Polecat Creek to W K Pl.

* Note that "Use of Existing Detailed Study" refers to the incorporation of an existing detailed study provided by the community and is considered new detailed. See Section 3.0 for details.

2.2 Community Description

The County is served by U.S. Highway 64 and 75, and Interstate Highway 44. Air service is provided by Tulsa's airport.

Unincorporated Areas

Tulsa County is located in northeastern Oklahoma. The City of Tulsa covers approximately one-third of Tulsa County. It is bordered by the unincorporated areas of Washington, Okmulgee, Rogers, Wagoner, Osage, and Creek Counties to the north, south, northeast, southeast, northwest, and southwest, respectively.

Tulsa County covers an area of 587 square miles and was created at statehood and named after the City of Tulsa. The City of Tulsa, established in 1879, was named for Tulsey Town, an old Creek Indian town in Alabama. A large part of Tulsa County is urban area. In the southern part of Tulsa County, there is excellent agricultural land, which is rapidly undergoing urban development. The northern part of the County played a dominant role in the early days of settlement, but its growth has not been as rapid during the last several decades. According to the U.S. Bureau of the Census, the population of Tulsa County was 563,299 in 2000 (Reference 2).

Tulsa County was originally part of Indian Territory, which consisted of territories west of the Mississippi River and included part of the Louisiana Purchase. Among the first settlers to arrive in Tulsa County were the Creek Indians, who were relocated from their land allocations in the southern states by directives from Congress in the early nineteenth century. Land runs that opened in 1889, 1891, and 1893 attracted large numbers of settlers. In 1897, oil was discovered in Bartlesville, approximately 34 miles north of Tulsa County, and the nature of the region changed with the influx of speculators, drillers, and wildcatters. Oil was discovered in west Tulsa County in 1901, which attracted investors from the east, thus making Tulsa County the main center of oil concern. The famous Glenn Pool oil field was discovered in southwestern Tulsa County in 1905 and, after 2 years of development, was the main reason Tulsa became known as the "Oil Capital of the World." Today, three major facets of the industrial base are manufacturing, petroleum, and aerospace. The Arkansas River Basin Navigation System has opened up new possibilities for industrial growth. Agriculture is also a major source of income for many people in the Tulsa County area.

The major pattern of development in Tulsa County is to the southeast, with increasing development occurring in the north and west. Most new construction is located in the incorporated communities of Tulsa County.

The Arkansas River flows from west to east, approximately 15 miles into Tulsa County. It then flows southeast through the County for approximately 25 miles. The 1,460-mile-long Arkansas River has a drainage area of approximately 74,500 square miles above Keystone Dam, of which approximately 22,350 square miles are considered to contribute to flood flows. The Arkansas River has its headwaters in west-central Colorado and flows in a southeasterly direction through Kansas, Oklahoma, and Arkansas to its confluence with the Mississippi River near Rosedale, Mississippi. Flows of the Arkansas River through the County are regulated by Keystone and Kaw Dams. The downstream study limit of the Arkansas River in Tulsa County is near RM 497.6, with the upper limit being Keystone Dam at RM 538.8. The unregulated drainage area between Keystone Dam and the lower study limits of the Arkansas River is approximately 650 square miles. Major tributaries of the Arkansas River are Berryhill, Fisher, Haikey, Polecat, and Snake Creeks.

Sand Creek is a left-bank tributary of the Arkansas River that generally drains to the south. The watershed of the creek is fairly steep, with wooded hills. Some minor development is scattered throughout the watershed.

Little Sand Creek is also a left-bank tributary to the Arkansas River that generally drains to the south. The watershed of the creek is fairly steep, with wooded hills. Some minor development is scattered throughout the watershed. The hilly expanses of the watershed have fairly shallow soils with some rock. The creek valley has sandy soil, especially in the lower reaches. The creek bed is shifting sand, with the banks fairly stable in the upper reaches but sandy and easily eroded in the lower 1 mile.

Bird Creek rises in Osage County approximately 106 stream miles northwest of Tulsa County and flows in a southeasterly direction approximately 149 stream miles to the Verdigris River. Bird Creek, within Tulsa County, extends from Stream Mile (SM) 9 through SM 43. Bird Creek covers a total drainage area of 1,137 square miles, with approximately 450 square miles being above Tulsa County. Birch and Candy Lakes control drainage areas of 43 and 66 square miles, respectively. The average streambed slope of Bird Creek through Tulsa County is approximately 2.5 feet per mile (fpm). Major Bird Creek tributaries are Charley, Delaware, Elm, Hominy, and Ranch Creeks.

The terrain in Tulsa County is mostly gently rolling hills, with broad expanses of flat land in the Arkansas River and Bird Creek floodplains. Generally, trees and brush grow in and adjacent to the stream channels. Vegetation includes native prairie grasses (big and little bluestem, switch grass, and side oats grams) and introduced species such as Bermuda grass and fescue. Trees include juniper, cedar, spruce, elm, blackjack, and varieties of oak. Outcrops are sedimentary rocks of Pennsylvanian age and consist of limestone, shales, and sandstones. Soils vary from residual materials in the upland areas to alluvial types in the floodplains and river terraces.

Weather in Tulsa County is generally temperate, with mild winters and occasional snow. The average annual precipitation in Tulsa County is 38 inches, the majority of which occurs as rain in the crop-growing season from April through September. The average annual temperature in Tulsa County is 61°F, with mean highs and lows of 82°F and 38°F, respectively. Extreme temperatures range from a low of -8°F in winter to a high of 112°F in summer.

City of Bixby

The City of Bixby is located in Tulsa and Wagoner Counties, approximately 16 miles southeast of downtown Tulsa and adjacent to the Arkansas River. According to the U.S. Bureau of the Census, the City of Bixby had a population of 13,336 in 2000 (Reference 2). The City of Bixby is primarily an agricultural city that has become a fast-growing suburb of the City of Tulsa, with most new residential development being in the northern part of the City in the Fry Ditch Nos. 1 and 2 and Haikey Creek watersheds. New residential areas are also being developed south of the Arkansas River in the Snake Creek floodplain.

The City of Bixby, founded in 1899, was named after Tams Bixby, Sr. Mr. Bixby was chairman of the Dawes Commission, which negotiated treaties with the Five Civilized Tribes and allocated land to individual members of the tribes. With the allocation of land and subsequent influx of settlers westward, small communities began to appear in this area. The City of Bixby, one such community, grew with the coming of the railroad in 1904 and was incorporated in 1908, one year after the statehood of Oklahoma.

Soil in the City of Bixby consists of silty sand and, in some areas, clay. The Arkansas

River flows through the middle of the City of Bixby corporate limits, just north of the central business district. The Haikey Creek and Fry Ditch water basins, with a combined drainage area of approximately 50 square miles, originate near 51st Street and flow generally south to the Arkansas River. White Church Creek is a left-bank tributary and Little Haikey Creek is a right-bank tributary of Haikey Creek. The upper reaches of the 36.7-square-mile Haikey Creek watershed are rolling pasture and farmland, with a small portion of the whole watershed in urbanized areas of the Cities of Bixby, Broken Arrow, and Tulsa. The average streambed slope of Haikey Creek is 18 fpm in the upper reaches and 6 fpm in the lowlands. Fry Ditch No. 1, with a drainage area of 5.7 square miles, is a right-bank tributary of Haikey Creek, while Fry Ditch No. 2 drains 7.3 square miles to its confluence with the Arkansas River. Approximately 15 percent of the Fry Ditch basin consists of urban residential developments, with most of the development located in the lower half of the watershed. The remainder of the Fry Ditch basin consists of truck farms, pastures, orchards, and undeveloped woodlands and bottomlands. The streambeds in the upper reaches of the Fry Ditch watersheds remain in their natural conditions while in the lowlands, the flows have been channeled into ditches with levees on both sides. The streambed slopes are approximately 25 fpm in the upper reaches and 5 fpm in the lowlands. The lower portions of the Fry Ditches and levees were constructed in 1908 to prevent flows from the upper basin from inundating agricultural lands. As the channel bottom between the levees of each Fry Ditch is above natural grade in many locations, local drainage is prevented from reaching the channel, thus compounding the flood problems.

The drainage areas of the City of Bixby south of the Arkansas River include Snake Creek, which has its headwaters near Beggs, Oklahoma, and drains 185 square miles in a northeasterly direction. The unnamed right-bank tributary of the Arkansas River, with its confluence near the mouth of Snake Creek, has a drainage area of approximately 4.5 square miles, with 0.5 square mile of the area developed where the City of Bixby central business district is located. The left-bank Snake Creek tributary has a drainage area of 5.9 square miles, with approximately 0.3 square mile being developed area. The Snake Creek watershed is hilly to gently rolling terrain and is largely used for pastureland. The valley is generally narrow and winding in the upper reaches, with a Snake Creek streambed slope of 6 fpm. The two unnamed tributaries and the lower reach of Snake Creek are located in the Arkansas River floodplain and have extremely flat terrain. The streambeds have an average slope of approximately 5 fpm. Posey Creek, west of the City of Bixby, has a drainage area of approximately 17 square miles of undeveloped land, with 1.5 square miles being within the corporate limits of the City of Bixby. Posey Creek has a streambed slope of approximately 10 fpm.

The City of Bixby has a small water supply and recreation lake southeast of the City known as Bixhoma Lake. The lake has no provision for flood-control storage.

City of Broken Arrow

The City of Broken Arrow is located in southeastern Tulsa County, approximately 12 miles southeast of downtown Tulsa, and borders the southeastern corporate limits of the City of Tulsa. According to the U.S. Bureau of the Census, the population of the City of Broken Arrow was 74,859 in 2000 (Reference 2). Commercial enterprises within the City include a Ford Glass Plant, insurance company headquarters, heat exchanger and machinery manufacturers, and various smaller businesses.

The drainage pattern of the City is dominated by Haikey and Broken Arrow Creeks and their tributaries, Adams Creek, and the Arkansas River. The Haikey Creek and Broken Arrow Creek stream systems flow south to the Arkansas River (which flows generally east in this area), approximately 6 miles south of the City. Adams Creek flows to the east to its confluence with the Verdigris River, approximately 12 miles east of the City of Broken Arrow.

City of Collinsville

The City of Collinsville is located in Tulsa and Rogers Counties, approximately 20 miles north of the City of Tulsa. According to the U.S. Bureau of the Census, the City of Collinsville had a population of 4,077 in 2000 (Reference 2).

In relation to the other communities in the Tulsa urban area, the City of Collinsville has the largest percentage of land zoned for industrial use, and its present economy is based primarily on industry. Many of the citizens of the City of Collinsville are employed in the City of Tulsa.

The Caney River originates in southern Kansas and flows generally in a southeasterly direction to its confluence with the Verdigris River south of Oologah Lake. The watershed is generally rolling pastureland, but some portions are wooded and hilly. The drainage area at the City of Collinsville is 2,046 square miles, and the stream slope through the area is flat, approximately 1 fpm. The floodplain, which affects the eastern edge of the City of Collinsville, is broad and flat.

Horsepen Creek, which flows to the north of the City of Collinsville, is a left-bank tributary of the Caney River. Horsepen Creek and its major tributaries, Blackjack and Cherry Creeks, drain an area that is generally rolling pastureland, with some hilly areas. The drainage area of the basin is 32.7 square miles, of which 10.5 miles are drained by Blackjack Creek. Horsepen Creek has a fairly flat average stream slope of 6.5 fpm, while Blackjack Creek has a slope of 11.3 fpm. The only intense development is in the City of Collinsville. Approximately half the City drains into the lower end of Blackjack Creek and the other half is drained by Blackjack Creek Tributary A, a right-bank tributary of Blackjack Creek with a drainage area of 1.6 square miles and an average stream slope of 27.5 fpm.

East Creek is also a left-bank tributary of the Caney River. Its basin is rolling pastureland, with some acreage development. It drains an area of 6.2 square miles and has an average stream slope of 17.4 fpm.

City of Glenpool

The City of Glenpool is located in southwestern Tulsa County. The City is bordered by the unincorporated areas of Creek County to the west, the City of Jenks to the east and north, and the unincorporated areas of Tulsa County to the east and south. According to the U.S. Bureau of the Census, the City of Glenpool had a population of 8,123 in 2000 (Reference 2). Coal Creek, a right-bank tributary of Polecat Creek, has its headwaters approximately 2 miles southeast of the City. The 7-mile-long creek, which flows northerly through the City, has an average streambed slope of 13 fpm and a drainage area of 13.4 square miles. Coal Creek Tributary A has a drainage area of 1 square mile and an average streambed slope of 41 fpm. Coal Creek Tributary B has a drainage area of 1.4 square miles and a streambed slope of 27 fpm. Posey Creek has a drainage area of 15.1 square miles and a streambed slope of 6 fpm. The left-bank tributary of Posey Creek has a drainage area of 1.6 square miles and a streambed slope of 30 fpm. For Nichols Creek, the drainage area is 0.7 square mile and the streambed slope is 40 fpm. For Rolling Meadows Creek, the drainage area is 0.3 square mile and the streambed slope is 36 fpm.

City of Jenks

The City of Jenks is located in Tulsa County, 9 miles south of downtown Tulsa. According to the U.S. Bureau of the Census, the population of the City of Jenks was 9,557 in 2000 (Reference 2).

The original City of Jenks townsite was platted on July 15, 1905, along the railroad that was constructed between Tulsa and Muskogee. The community's location was further enhanced by the proximity of the Arkansas River, which was navigable by shallow draft streamboats when the river level was high. The new town was most influenced by the railroad. The town was named after Elmer Ellsworth Jenks, M.D., who came to the area in 1902 and immediately established the Jenks Post Office, which laid the groundwork for the plat of the original townsite of the City of Jenks.

The City of Jenks experienced rapid growth in 1906 immediately after the discovery of oil in nearby Glenpool. Oil was discovered near the City of Jenks in 1912, and petroleum extraction and distribution were established as primary industries in the town. After the depletion of oil in the Jenks area, farming regained importance. The role of agriculture in the area was further strengthened with the immigration to the Jenks area of a sizeable settlement of Bulgarian farmers and their families in the 1920s. Truck farming, livestock production, and dairying became the dominant activities, while the City still remained a somewhat agricultural community. The City of Jenks has several industries that provide employment. Many of the citizens of the City of Jenks are employed in the City of Tulsa.

The Arkansas River flows in a southerly direction along the eastern edge of the City of Jenks. Polecat Creek, a right bank tributary of the Arkansas River, flows in a southeasterly direction south of downtown Jenks. Polecat Creek has a drainage area of 369 square miles and an average streambed slope of 2 fpm. The watershed is gently rolling to hilly woodlands and pasture, with a flat valley constricted by the natural terrain and Jenks Levee. A right-bank tributary of the Arkansas River called Wilmott Creek flows south through the downtown area of the City of Jenks. Wilmott Creek drains 1 acre of urbanized area within the Jenks Levee. The channel has been improved by local interests and drains into a ponding area inside the levee. The average streamed slope through the study area is 5 fpm. Posey Creek flows from south to north, then east through the City of Jenks to its confluence with the Arkansas River.

The creek has a drainage area of 15.1 square miles and a streambed slope of 6 fpm. The left-bank tributary of Posey Creek has a drainage area of 1.6 square miles and a streambed slope of 30 fpm. The watershed terrain is gently rolling hills of pastureland with some wooded areas along the streams.

City of Owasso

The City of Owasso is located in Tulsa and Rogers Counties, approximately 12 miles northeast of the City of Tulsa. According to the U.S. Bureau of the Census, the City of Owasso had a population of 18,502 in 2000 (Reference 2).

The community could be characterized as being overzoned commercially and there is very little industry in the City. The commercial zone mainly straddles the Mingo Valley Expressway. Many of the citizens of the City of Owasso are employed in the City of Tulsa, and nearly half of the employed population is in white-collar occupations.

Bird Creek originates in Osage County, in northeastern Oklahoma, approximately 55 miles northwest of the City of Owasso, and flows in a southeasterly direction approximately 106 stream miles to its confluence with the Verdigris River. The City of Owasso is located just north of the creek, approximately 13 stream miles above the confluence. The Bird Creek drainage basin contains 1,137 square miles of area, approximately 1,023 of which are above the City of Owasso, and the average stream slope is 6.4 fpm. In the area near the City, the stream slope is very gentle, averaging approximately 4 fpm, and the creek flows through a broad, well-defined floodplain. The stream meanders a great deal and has a broad channel with high banks.

Two left-bank tributaries of Bird Creek within the City of Owasso corporate limits are Bird Creek Tributary 5A and Elm Creek. The Elm Creek basin is fairly flat pastureland, with some acreage development. Bird Creek Tributary 5A is the most-developed basin, draining most of the City of Owasso. Further residential development is rapidly occurring, with considerable realignment and reshaping of the channel. The undeveloped upper portion of the basin is fairly steep pastureland. The drainage areas are 19 and 2.7 square miles for Elm Creek and Bird Creek Tributary 5A, respectively. The average stream slopes for Elm Creek and Bird Creek Tributary 5A are 19.2 and 21.9 fpm, respectively.

Ranch Creek and Ranch Creek Tributary A are also left-bank tributaries of Bird Creek. Ranch Creek lies just west of the Atchison, Topeka, and Santa Fe Railway west of the City of Owasso. The lower 1-½ miles of the stream lie in the Bird Creek floodplain. The eastern portion of the basin is rolling pastureland, while the western portion is more hilly with some woods, mainly along the streams. The drainage area of Ranch Creek is 12.6 square miles, while Ranch Creek Tributary A drains 1.3 square miles. The stream slopes are 12.4 fpm for Ranch Creek and 49.2 fpm for Ranch Creek Tributary A.

City of Sand Springs

The City of Sand Springs is located in Tulsa and Osage Counties, 8 miles west of downtown Tulsa. According to the U.S. Bureau of the Census, the City of Sand Springs had a population of 17,451 in 2000 (Reference 2).

In approximately 1911, the City of Sand Springs was settled by a group of Creek Indians who named it after a nearby spring. The present economy of the City of Sand Springs is based primarily on manufacturing and service industries. Many of the citizens of the City of Sand Springs are employed in the City of Tulsa.

The City of Sand Springs contains a wide variety of terrain and soil types, ranging from gently sloping alluvial soils in the Arkansas River floodplain to rough rocky areas containing slopes in excess of 21 percent, found primarily in the northern part of the community.

Fisher and Anderson Creeks lie in the hills and uplands southwest of the City of Sand Springs. Fisher Creek flows from its headwaters downstream approximately 4 miles to the Arkansas River floodplain where it turns and flows parallel to the Arkansas River for 2.5 miles to the confluence of Anderson Creek, and another 0.5 mile to the Arkansas River. Fisher and Anderson Creeks have an average str eambed slope of 18.5 fpm. Some residential and commercial development has occurred in the formerly agricultural lands along Fisher Creek in the old Arkansas River floodplain.

West Bigheart Creek flows south and east into Bigheart Creek, which is a left bank tributary of the Arkansas River, approximately 3 miles downstream of Sand Springs. The watershed of this stream is similar to that of Euchee Creek. There is some light development scattered throughout the watershed. The lowest reach of the stream flows along the flat Arkansas River floodplain. The runoff from 0.7 square mile is controlled by

Sand Springs Lake.

Town of Skiatook

The Town of Skiatook is located approximately 16 miles north of the City of Tulsa, in northwestern Tulsa County and southeastern Osage County. The Town of Skiatook began as a general store or trading post in what was then the Cherokee Nation Indian Territory. W.C. Rogers, the last principal chief of the Cherokee Tribe, opened the store in approximately 1880 near a spot where Bird Creek was easily crossed. The town name Ski-A-Took, a compound word taken from the Cherokee language, is generally accepted as meaning Big Injun Me. In April 1892, the spelling was officially changed to Skiatook. On May 29, 1905, the area was incorporated as “Skiatook Indian Territory,” with a population of 200.

According to the U.S. Bureau of the Census, the Town of Skiatook had a population of 5,396 in 2000 (Reference 2). The trend of the Town's growth is to the west into Osage County, away from the Bird Creek floodplain. The John Zink Company, builder of industrial heaters, is the principal employer in the community. Agriculture and oil development are also major industries in the Town of Skiatook.

Bird Creek rises in Osage County in northeastern Oklahoma, approximately 45 miles northwest of the Town of Skiatook, and flows southeasterly approximately 106 stream miles to its confluence with the Verdigris River. The Town of Skiatook is located approximately 37 stream miles above the confluence. The average streambed slope of Bird Creek through the Town of Skiatook is approximately 3 fpm.

Bird Creek has 461 square miles of drainage area above the lower end of the Town of Skiatook. Birch and Candy Lakes control 43 and 66 square miles, respectively, leaving 3 52 square miles of contributing drainage area above the Town of Skiatook.

The terrain in the Skiatook area consists of gently rolling hills, with a heavy concentration of Oklahoma's native grasses, brush, and trees. The flat plain areas of the watershed support a heavy growth of grass with few trees. The floodplain area of Bird Creek is used for agricultural and grazing purposes, with trees and brush growing in and adjacent to the Bird Creek channel. Rock formations outcropping in the Bird Creek basin are of Pennsylvanian age and consist of limestones, shales, and sandstones. The area also contains extensive oil and gas development that has been in operation for several years.

Town of Sperry

The Town of Sperry is located in Tulsa and Osage Counties, 11 miles north of downtown Tulsa. According to the U.S. Bureau of the Census, the Town of Sperry had a population of 981 in 2000 (Reference 2).

The general area was originally part of Indian Territory, which was composed of the territories west of the Mississippi River and included in the Louisiana Purchase. Urban development in the Town of Sperry consists of low-density residential development (Reference 3). The present economy of the Town of Sperry is based primarily on manufacturing and service industries. Many of the citizens of the Town of Sperry are employed in the City of Tulsa.

Bird Creek originates in Osage County, in northeastern Oklahoma, approximately 50 miles northwest of the Town of Sperry, and flows in a southeasterly direction approximately 106 stream miles to its confluence with the Verdigris River. The Town of Sperry is located just west of Bird Creek, approximately 27 stream miles above its confluence. The Bird Creek drainage basin contains 1,137 square miles of area, approximately 900 of which are above the Town of Sperry. The average stream slope is approximately 6 fpm. In the area near the Town of Sperry, the stream slope is very gentle, averaging approximately 4 fpm, where the creek flows through a broad, well-defined floodplain. The stream meanders a great deal and has a broad channel with high banks. It is a mature, perennial stream, with a well-developed meandering pattern. The natural characteristics of the upper reaches of the basin, where the slopes are steep and the valley is narrow, result in rapid runoff during heavy rainfall. In the lower reaches, with the meandering channel, flat slopes, and dense vegetation, the runoff is slow and overbank flooding occurs an average of twice annually.

Two west-bank tributaries of Bird Creek border the corporate limits of the Town of Sperry. They are Hominy Creek, to the north of Sperry, and Delaware Creek, to the south of Sperry. The two streams are characteristically similar to Bird Creek.

Hominy Creek has a total drainage area of 415 square miles and a streambed slope through the study area of approximately 2 fpm. Downstream of Cincinnati Avenue, the channel is winding and shares a broad, flat, poorly drained floodplain with Bird Creek. Most of the land in the basin upstream of Cincinnati Avenue is hilly and used for pasture or agriculture.

Delaware Creek has a drainage area of 51.6 square miles and an average streambed slope of approximately 6 fpm. Downstream of Cincinnati Avenue, Delaware Creek shares the broad floodplains of Bird and Hominy Creeks. Upstream of Cincinnati Avenue, the floodplain is approximately 0.5 mile wide. Most of the basin is very hilly and wooded.

City of Tulsa

The City of Tulsa, the second-largest city in Oklahoma, is located in Tulsa, Osage, and Rogers Counties, in northeastern Oklahoma. The City of Tulsa lies approximately 90 miles northeast of the City of Oklahoma City. Nearby communities include the City of Bixby and Cities of Broken Arrow and Sand Springs. According to the U.S. Bureau of the Census, the population of the City of Tulsa was 393,049 in 2000 (Reference 2).

The drainage pattern of the City of Tulsa is dominated by the Arkansas River and Bird Creek and their tributaries. Watershed Units 10, 11, and 13 drain south into the Arkansas River and Unit 12 drains east to the river. Watershed Units 7 and 8 drain east and north, respectively, into Bird Creek.

The major pattern of development is in the southeast. Large areas of the City of Tulsa lie within the existing 1-percent-annual-chance floodplain, with the largest floodplain development located in the Mingo Creek watershed (Watershed Unit 8).

2.3 Principal Flood Problems

Unincorporated Areas

Several floods have occurred in Tulsa County. Major floods on the Arkansas River occurred in 1908, 1923, 1957, and 1959. According to a water-stage recorder gage located on the 11thStreet bridge, the flood peak of record occurred on October 5, 1959. That peak flow was estimated to be 246,000 cubic feet per second (cfs), approximately a 0.7-percent-annual-chance flow with Keystone Dam in place. The second largest recorded flow was 244,000 cfs in June 1923. Numerous floods have occurred in the Bird Creek basin in northern Tulsa County. The flood of October 3, 1959 was the largest flood recorded at the Sperry gage located on 86th Street North (RM 25.0). For that flood, a 90,000-cfs discharge was recorded that was approximately a 1-percent-annual-chance flow for natural conditions. Other major floods occurred on Bird Creek in 1876, 1915, 1942, 1943, 1957, 1960, 1961, and March and November 1974.

The record flood on the Caney River at the Ramona gage (RM 32.0) occurred on May 21, 1943, prior to the construction of Hulah Dam, when the estimated peak flow was 91,000 cfs. The largest flood since the construction of Hulah Dam occurred in 1974 and produced a peak discharge of 38,400 cfs.

The largest flood of recent years on Anderson, Berryhill, and Fisher Creeks occurred in June 1974. No stream gages are located in the watershed; however, high-water marks on Fisher Creek indicated flood levels were near the computed 2-percent-annual-chance flood in some areas. Residences and businesses along Fisher Creek sustained approximately $80,000 in damages. The Berryhill community suffers some flood damage approximately once a year from Berryhill Creek and its tributary. The June 1974 flood caused an estimated $97,000 in damages there, and one death was attributed to that flood.

The lower end of Haikey Creek in Tulsa County has had major flooding in recent years. The two most severe floods on Haikey Creek occurred on June 8, 1974, and May 30, 1976. Based on high-water marks, the June 1974 flood was the most severe for the lower reach; however, the two floods were approximately the same magnitude upstream. In some places, high-water marks for each flood were near the computed 2-percent-annual-chance flood elevations. For the entire Haikey Creek watershed, the May 1976 flood caused an estimated $830,000 in damages (Reference 4).

A wire-weight gage is located on Polecat Creek at Sapulpa, approximately 20 stream miles above Tulsa County. Based on high-flow readings at this gage, the flood of June 8, 1974, is the highest discharge on Polecat Creek since the completion of Heyburn Dam in 1950. The estimated record flow of 33,500 cfs at Sapulpa is approximately a 3.3-percent-annual-chance flood. The June 8, 1974, high-water marks on Posey Creek were close to computed 2-percent-annual-chance elevations. Flooding has also occurred on other creeks in Tulsa County.

The majority of flooding in Tulsa County is caused by intense rainfall resulting from local thunderstorms. The amount of flooding is generally increased in areas where natural and manmade obstructions in the floodplain impede large flows. Manmade obstructions include bridges, culverts, earthfill, and building developments. Natural obstructions include dense vegetation, constrictions in the floodplain topography, and meandering channels.

City of Bixby

The flood of May 1976 is considered the flood of record for Haikey Creek and Fry Ditch Nos. 1 and 2. This flood caused estimated monetary damages of $770,000 for residential (consisting of 64 houses), $40,000 for commercial, and $20,000 for agricultural, totaling $830,000 for the Haikey Creek watershed. For the Fry Ditch No. 2 watershed, the flood caused estimated monetary damages of $60,000 for residential (consisting of five houses) and $10,000 for agricultural, totaling $70,000. The flood of June 8, 1974 caused an estimated $650,000 of damage for the Haikey Creek watershed. The flood of October 1959 caused an estimated $513,000 of damage for the Arkansas River watershed within the City of Bixby. The flood of May 1957 caused an estimated $500,000 of damage at the Arkansas River watershed within the City of Bixby.

Since 1970, a crest-stage gage has been located on the right bank of Snake Creek at RM 11.0. A continuous-record stream gage was located at the same location from 1962 to 1970.

Floods occurred on Snake Creek on April 13, 1967; January 29, 1969; April 30, 1970; September 6, 1971; December 15, 1971; June 9, 1974; and November 4, 1974. The flood of record at the Snake Creek gage was the June 9, 1974 flood, with a peak flow of 9,280 cfs.

Because there are no stream gages for the remaining creeks in the City of Bixby, limited flood data are available on Haikey Creek and Fry Ditch Nos. 1 and 2. Significant floods occurred on those streams in 1943, 1970, 1974, and 1976. High-water marks are available for the floods of June 8, 1974, and May 30, 1976. The two most recent floods were the largest known floods of recent years, with the 1974 flood having a higher stage on the lower end of Haikey Cr eek and the 1976 flood having a higher stage near the upper study limit. The majority of severe flooding in the City of Bixby area is caused by intense rainfall resulting from local thunderstorms. The amount of flooding is generally increased in areas where natural and manmade constrictions in the floodplain impede large flows.

City of Broken Arrow

Flooding has occurred several times in the vicinity of the City of Broken Arrow. Major flooding on the Arkansas River occurred in the vicinity of Tulsa in 1926, 1933, and 1944. A water-stage recorder gage is located on the Arkansas River at the 51st Street bridge, located approximately 14 river miles upstream from the portion of the Arkansas River restudied. The flood of record was recorded at the Tulsa gage on October 5, 1959, with a peak flow of 246,000 cfs.

Because there are no stream gages on the smaller streams in the City of Broken Arrow, limited flood data is available for Adams, Broken Arrow, and Haikey Creeks. However, local records show that significant flooding occurred along these streams in 1943, 1970, 1974, and 1976. High-water marks are available for the floods of June 8, 1974, and May 30, 1976. These two floods were the largest recorded along the previously mentioned streams. The 1974 flood had a higher stage on the lower end of Haikey Creek and the 1976 flood had a higher stage near the upper study limit.

The flood of October 5, 1959, on the Arkansas River had an annual chance of recurrence of between 10- and 2-percent. The May 30, 1976, flood along Haikey Creek had an annual chance of recurrence of between 10- and 5-percent. The most severe floods in the area of the City of Broken Arrow are caused by intense rainfall resulting from local thunderstorms. The amount of flooding is generally increased in the areas where natural and manmade obstructions in the floodplains impede large flows.

City of Collinsville

The flood of record on the Caney River at the City of Collinsville occurred on May 21, 1943, and had a peak discharge of 91,000 cfs at the Ramona gage. Hulah Lake was constructed in 1951. The largest flood since that time occurred on March 11, 1974, and produced a peak discharge of 38,400 cfs at the Ramona gage. By comparison, the present 1-percent-annual-chance discharge measured at the Ramona gage, as modified by Hulah and Copan Lakes, is Other streams in the study area are small and ungaged, and flood data are virtually nonexistent. No high-water marks were located, and the storms that caused severe flooding in Tulsa in recent years did not significantly affect the areas in the City of Collinsville.

City of Glenpool

There are no gages on the streams studied in the City of Glenpool. Therefore, only limited flood information is available. There have been no major flood problems in the developed sections of the City.

City of Jenks

The first damaging flood in the City of Jenks occurred in 1908, although flooding on the Arkansas River was common prior to the City's existence. Another major flood occurred in 1923, and floods continued to plague the City until the Jenks Levee was completed in 1949. A water-stage recorder gage is located on the Arkansas River at the 11th Street bridge (Alternate U.S. Highway 66), 8 miles upstream from the City of Jenks.

The flood of record occurred on October 5, 1959, when the peak flow of the Arkansas River was 246,000 cfs, only 2,000 cfs more than the June 1923 flood. This would be approximately a 0.7-percent-annual-chance flow with Keystone Dam in place. The following is a list of other peak recorded flows at the Tulsa gage:

Date	Peak Flow (cfs)
May 21, 1957	235,000
May 19, 1957	213,000
May 25, 1908	212,000
May 20, 1943	173,000
April 26, 1944	172,000
October 1, 1945	165,000
May 9, 1961	164,000
September 15,1961	154,000

A wire-weight gage is located on Polecat Creek at Sapulpa, approximately 20 stream miles above the City of Jenks. Based on high-flow readings at this gage, the flood of June 8, 1974 is the highest discharge on Polecat Creek since the completion of Heyburn Dam in 1950. The estimated discharge of 33,500 cfs at Sapulpa is approximately a 3.3-percent-annual-chance flood. There are no gages on the remaining streams in the City of Jenks; therefore, only limited flood information is available.

City of Owasso

A gaging station was located on Bird Creek near the City of Owasso from 1935 to 1937. The Owasso gage was abandoned, and the data declared unreliable due to backwater effects. A gaging station on Bird Creek near Sperry (RM 24.8) was used for the study in the City of Owasso. The flood of record at this gage occurred on October 3, 1959, when the recorded discharge was 90,000 cfs for natural conditions. That was approximately a 1-percent-annual-chance discharge. With the existing and proposed flood-control structures complete, the October 1959 flow would be reduced to 43,000 cfs at the Sperry gage. The second largest recorded flow at Sperry was 72,200 cfs in May 1943. Two more recent large floods occurred in November and March 1974, with recorded flows of 54,000 and 45,500 cfs, respectively. Highwater marks for the November 1974 flood obtained at various locations along Bird Creek in the vicinity of the City of Owasso were used for the study. The remaining streams in the study area are small and ungaged; therefore, no flood data are available.

City of Sand Springs

The most extensive flooding known to have occurred in the City of Sand Springs in recent history happened in May 1984 and September and October 1986. Damages sustained in the May 1984 flood in the City of Sand Springs area were $10,551,000. No gaged flood records exist for flooding conditions in this area. The flood of record for the Arkansas River occurred in September and October 1986, when a discharge of 300,000 cfs was recorded. Storm-drainage problems are for the most part confined to the central business district. The majority of the official floodplain designation occurs south of the Arkansas River in the Anderson and Fisher Creek drainage areas.

Town of Skiatook

The major flood problems in the Town of Skiatook have been caused when high water in Bird Creek backs up water in North and South Fork Horse Creeks, with the resulting overflow spreading into town from the north and east. The flow of record occurred in October 1959, and resulted from a storm that began around midnight, October 1, in which 8.3 inches of rain fell, with 6.3 inches falling in the first 24 hours and an additional 2 inches falling in the ensuing 48 hours. Flood waters were up to 7.5 feet deep in low parts of town and 4 feet deep in many homes and businesses. Property and structures subjected to flooding comprised an area of 124 acres. Major floods also occurred in 1943, 1945, 1948, 1950, 1953, 1954, 1957, 1960, 1961, 1971, and 1974. The discharge on Bird Creek from the October 1959 flood was estimated at 44,000 cfs at Skiatook, which was approximately a 2.5-percent-annual-chance flood. The most recent large flood in the Town of Skiatook occurred in March 1974. This flood was estimated to have a flow of 30,000 cfs, which was approximately an 8.3-percent- annual-chance flood. These figures are based on conditions prior to construction of Birch, Candy, and Skiatook Lakes.

Town of Sperry

No flood records exist for the Town of Sperry, but records do exist for a gage on Bird Creek located 2.5 miles downstream of the Town of Sperry, on the 86th Street North bridge. The flood of record at this gage occurred on October 3, 1959, when a discharge of 90,000 cfs was recorded. For natural conditions, that was approximately a 1-percent-annual-chance discharge. The gage height reached an elevation of 612 feet above National Geodetic Vertical Datum of 1929 (NGVD) (Reference 5). With the existing and proposed flood-control structures complete, the October 1959 flow would be reduced to 43,000 cfs at the Sperry gage. Other major floods are known to have occurred on Bird Creek in 1876, 1915, 1942, 1943, 1957, 1960, 1961, and March and November 1974.

A substantial area of the Town of Sperry is subject to the flood waters of Bird Creek during a1-percent-annual-chance flood. The roads connecting Sperry to Tulsa would be inundated by the 1-percent-annual-chance flood. The Town has been isolated during floods in the past.

City of Tulsa

Several major floods have occurred in the Tulsa area. Major flooding on the Arkansas River occurred in 1908, 1923, 1957, and 1959. A water-stage recorder gage is located on the river at the 11th Street bridge. The peak flood of record at the gage occurred on October 5, 1959, with a peak flow estimated at 246,000 cfs. The flood at the gage (for non-regulated conditions) had an annual chance of recurrence of approximately a 4-percent.

Numerous floods have occurred in the Bird Creek basin. The flood of October 3, 1959 is the largest flood of record at the Sperry gage (8th Street North), with a peak discharge of 90,000 cfs, which is estimated to be the 1-percent-annual-chance event under natural conditions. Severe floods also occurred in 1943, and two floods occurr ed in 1974. Various amounts of overbank flooding have occurred approximately every 6 to 7 years.

Floods have also occurred on the other streams studied by detailed methods. The two most severe floods on Haikey Creek and its tributaries occurred on June 8, 1974, and May 30, 1976. The June 1974 flood was the most severe on the lower end of the watershed. The May 1976 flood had an annual chance of recurrence of between 10- and 5-percent. The Mingo

Creek watershed also experienced severe flooding in June 1974 and May 1976. The May 1976 flood was the flood of record for Mingo Creek. Two annual chances of recurrence were estimated for the flood, from 10-percent in the lower basin to 1-percent in the upper areas.

Major flooding has also occurred along Joe, Flat Rock, Dirty Butter, and Cherry Creeks. The June 1974 and May 1976 floods were the most severe on Joe Creek, while the June 22, 1979 flood was the most severe on Dirty Butter Creek. The flood of record for Flat Rock Creek occurred on July 15, 1961. The annual chance of recurrence of the May 1976 flood on Joe Creek was estimated at approximately 2-percent.

2.4 Flood Protection Measures

Unincorporated Areas

Major flood-control projects on the Arkansas River above Tulsa County include Keystone and Kaw Lakes and the John Martin Reservoir. Several small dams are located on tributaries of the Arkansas River, but Keystone and Kaw Lakes are the only projects considered to have significant effects on the Arkansas River flows in Tulsa County. Keystone Dam, completed in September 1964, is the upper limit of study of Tulsa County at RM 538.8. Kaw Lake, located115 river miles upstream from Keystone Lake, began operation in April 1976. Keystone and Kaw Lakes were constructed by the USACE for purposes of flood control, water supply, power production, recreation, and fish and wildlife. Keystone Lake was also constructed for navigation purposes. Keystone and Kaw Lakes reduce the Arkansas River natural 1-percent-annual-chance flood flows of 360,000 cfs to approximately 170,000 cfs at the Tulsa (11thStreet) gage.

The Bird Creek basin has two major flood-control projects that affect flows in Tulsa County. Those projects, constructed for flood-control, water-supply, water-quality, fish and wildlife, and recreation purposes, are Skiatook and Birch Lakes. Skiatook Lake was completed by the USACE in October 1984 along Hominy Creek, approximately 5 miles above the Tulsa County boundary. The lake controls 354 square miles of drainage area. Birch Lake was completed by the USACE in March 1977. The dam is located on Birch Creek, which enters Bird Creek approximately 23 stream miles above the Tulsa County boundary. Birch Dam controls 66 square miles of drainage area. The effects of this flow reduction will diminish downstream because of the intervening uncontrolled drainage area.

Two multiple-purpose dams and reservoirs are located in the Caney River watershed. Hulah Lake, located approximately 36 miles northwest of the City of Collinsville, was completed in1951. The dam, located at RM 96.2 of the Caney River, was constructed for purposes of flood control, water supply, low-flow regulation, and other conservation purposes. Copan Lake is located on SM 7.4 of the Little Caney River, approximately 32 miles northwest of the City of Collinsville. The purposes of the lake are flood control, water supply, water quality, fish and wildlife, and recreation. Copan Lake became operational in April 1983 and is reflected in this study. Copan and Hulah Lakes are both USACE projects and together will control 1,237square miles of drainage area.

The Caney River natural 1-percent-annual-chance flow of approximately 80,000 cfs was reduced to 36,000 cfs by the Hulah and Copan Reservoirs. Those figures for the Ramona gage can be compared to the March 1974 recorded discharge of 38,400 cfs.

Heyburn Dam was constructed by the USACE at RM 48.6 of Polecat Creek. The lake controls 123 square miles of drainage area and provides flood-control storage for a 1-percent-annual-chance flood. Heyburn Lake was completed for full flood-control regulation in September 1950. In conjunction with the Heyburn Lake project, the Polecat Creek channel was cleared of snags and debris from its confluence with Arkansas River to approximately RM 21.0. The increased flow efficiently provided by the channel improvement has been reduced through the years due to lake of maintenance. The Tulsa-West Tulsa local flood-protection project was constructed in Tulsa County near the Cities of Sand Springs and Tulsa. The project included the construction of approximately12.4 miles of levees on both sides of the Arkansas River. The levees were built prior to February 1938, while improvements and additions were completed in spring 1945. On the left bank of the Arkansas River, the levee extends from RM 526.7 downstream to RM 521.3. The project was designed to provide 3 to 4 feet of freeboard with a discharge of 350,000 cfs. This would be approximately a 0.4-percent-annual-chance flood under present conditions.

A small flood-retarding structure has been constructed by the Natural Resources Conservation Service (NRCS) (formally the Soil Conserrvation Service) on a tributary of Fry Ditch No. 1, but it has not substantially reduced flood flows.

There are no flood-protection structures located in the Adams or Broken Arrow watersheds. In the Haikey Creek watershed, there is a levee that protects a portion of the Hickory Hills neighborhood in the vicinity of South 129th Avenue East. Also, portions of Haikey and Middle Branch Haikey Creeks have been channelized to reduce local flooding problems.

There are no major flood-control structures in the Coal Creek watershed. Several farm ponds, from 1 to 5 acres in size, are located in the watershed, but do not provide significant flood protection.

In February 1949, the USACE completed construction of the Jenks Levee. The project was authorized for construction on December 22, 1944 (Public Law 534, 78th Congress, 2nd Session). The levee was built to provide protection from a discharge of 350,000 cubic feet per second on the Arkansas River with a freeboard of 1.5 feet and a discharge of 45,000 cfs on Polecat Creek with a freeboard of 1.5 to 3.0 feet. The interior area in the Wilmott Creek basin drains south to a ponding area near Elm Street.

The design flow for the Jenks Levee is 45,000 cfs for Polecat Creek and 350,000 cfs for the Arkansas River. This would be approximately a 0.4-percent-annual-chance flood under present conditions. The top of the levee varies from 2 feet below to 2 feet above the 0.2- percent-annual-chance flood elevation. The Birch, Skiatook, and Candy system of lakes would reduce the October 1959 flow at the Sperry gage from 90,000 to 43,000 cfs.

Several farm ponds are located within the watershed around the City of Owasso, but they do not provide significant flood protection. Candy Dam is located on Candy Creek, which enters Bird Creek approximately 24 stream miles upstream from the Town of Sperry. Candy Dam controls 43 square miles of the 905-square-mile natural Bird Creek drainage basin. Analysis shows that Candy Lake has very little effect on Bird Creek water-surface profiles.

Flood-protection projects for the City of Tulsa have been built on Flat Rock, Valley View, Mingo, Cherry, and Red Fork Creeks. The Flat Rock Creek project (built by the USACE) consists of approximately 1.2 miles of channel modifications on Flat Rock Creek from Peoria Avenue to Cincinnati Avenue. Approximately 0.8 mile of channel on Valley View Creek was also modified. The Flat Rock Creek project provides protection from the 2-percent-annual-chance flood.

Several portions of the Mingo Creek channel have been straightened and widened to reduce flooding along the creek. The modifications were made by land developers and by the City, and they provide protection against the 2-percent-annual-chance flood for various areas.

The Cherry Creek flood-protection project, which was constructed by the USACE in November 1969, consists of 5,300 feet of channel modifications along Cherry Creek and approximately 1,300 feet of channel modifications along Red Fork Creek. Studies have shown that the project provides protection against a 2- to 10-percent-annual-chance flood, depending on the location along the creek.

Joe Creek has been channelized and straightened from its confluence with the Arkansas River to a point near East 66th Street. The channel modification was performed by local land developers and will contain a flood having an annual chance of recurrence of approximately 1-percent. Additional channelization is being done by the USACE along Joe Creek, from East 66th Street upstream to 51st Street. The modified channel will carry the 1-percent- annual-chance flood.

In addition to the structural measures mentioned above, several small agricultural levees are located in the study area. These levees were assumed to remain in place during flooding conditions.

In addition to the above structural measures, several small agricultural levees are located in the study area. These levees were assumed to remain in place during flooding conditions. Tulsa County; the Cities of Bixby, Broken Arrow, Collinsville, Glenpool, Jenks, Owasso, and Tulsa; and the Town of Skiatook also employ various nonstructural measures to reduce flood damages and prevent future losses such as the use of flood-zoning ordinances, subdivision regulations, building permits, and flash-flood warnings.

FEMA specifies that all levees must have a minimum of 3 feet of freeboard against 1-percent-annual-chance flooding to be considered a safe flood-protection structure. The levee on Haikey Creek meets FEMA freeboard requirements.

3.0 ENGINEERING METHODS

Flood events of a magnitude that is expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term, average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood that equals or exceeds the 1-percent-annual-chance flood in any 50-year period is approximately 40 percent (4 in 10); for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish peak discharge-frequency relationships for each flooding source studied by detailed methods affecting the community.

Natural flood flow frequencies for portions of the Arkansas River were based on a statistical analysis of peak flows at the Tulsa gage for the period from October 1904 through September1964. Keystone Lake inflows were used from September 1964 through September 1975. Methods outlined in U.S. Water Resources Council Bulletin No. 17B, "Guidelines for Determining Flood Flow Frequency," were used in developing the natural frequency curve without regulation by Keystone and Kaw Lakes (Reference 6). Hypothetical flows were developed for regulated conditions for the period from 1940 to 1975 using the reservoir system simulation model SUPER (Reference 7). Those flows were used to derive a frequency curve for modified conditions showing the effects of Keystone and Kaw Dams.

The Ramona gage is located on the Caney River at SM 32.0. It records stream data for a drainage area of 1,955 square miles, with a period of record from 1927 to the present (noncontinuous). The unregulated flows at the Ramona gage from 1927 to 1950 were used to develop a natural frequency curve for the Caney River using Bulletin No. 17B (Reference 6). A regulated frequency curve was then developed using gage data from 1950 to 1976 to determine the effects of Hulah Lake and estimating the additional effects of Copan Lake. The resulting frequency curve reflects flows modified by Hulah and Copan Lakes.

Flood flow-frequency data for Polecat Creek were based on a statistical analysis of estimated peak flows at the Sapulpa wire-weight gage. This gage was operated by the USACE for the period from February 1943 to the present. That analysis was also based on methods outlined by the U.S. Water Resources Council, with adjustments for expected probability, as outlined in "Statistical Methods in Hydrology" (Reference 8). This information, as used in the Flood Insurance Study for the City of Sapulpa, Oklahoma, dated June 15, 1981 (Reference 9), had been developed previously; therefore, no new studies without expected probability were developed.

The gage at Snake Creek was not used to determine the unit hydrograph coefficients for recorded floods due to inadequate rainfall data. Because of the relatively small drainage area at the gage, and the limited amount of data, the gaged record was not useful in determining discharges for the study area.

Natural flood flow frequencies for portions of Bird Creek were based on a statistical analysis of peak flows at the Sperry gage for the period from 1939 through 1976. The modified flows were then developed by modeling design storms with and without regulation for the Sperry gaging station and downstream locations.

A stream gage is located on Bird Creek near Sperry (RM 25.0), with a period of record from March 1939 to the present. Stream gages are also located on Bird Creek at Avant (RM 54.2) and Hominy Creek near Skiatook (RM 16.7), with periods of record from August 1945 and March 1944 to the present, respectively.

Flood flows on Bird and Hominy Creeks at Sperry were derived by hydrologic comparisons with the gaged flows on Bird Creek at Avant and Sperry and Hominy Creek near Skiatook. These comparisons were made using the USACE HEC-1 computer program (Reference 10). The program variables were developed from other studies and by the reconstitution of several flood hydrographs at the Avant, Sperry, and Skiatook gages. The discharge-frequency relationship for floods at the gages was developed by a log-Pearson Type III analysis of the peak annual flows. Modifications were made for regulation by Birch, Candy, and Skiatook Lakes. Expected probability was not used in the analysis.

The natural frequency curve for Bird Creek at the City of Owasso was developed using a logPearson Type III analysis of the Sperry gage and a HEC-1 basin model calibrated by using several historical storms (References 11 and 10, respectively). The HEC-1 model was then modified to reflect regulation of upstream reservoirs. A modified frequency curve for Bird Creek at the City of Owasso was then established.

In the original Flood Insurance Study for the City of Sand Springs dated December 15, 1980 (Reference 12), a discharge-frequency curve of the Arkansas River, modified by Keystone and Kaw Lakes, was developed using the USACE SUPER computer program (Reference 7). This computer program was used to simulate modified average daily flows at the Tulsa gage for the period from January 1, 1940 to December 31, 1974. The modified frequency curve was developed graphically from the simulated flows.

Hydrologic analyses were carved out to establish peak discharge-frequency relationships for Horsepin and South Fork Horse Creeks. The USACE HEC-1 computer program was used to establish peak discharges having recurrence intervals of 10, 50, 100, and 500 years (Reference 10). As part of these analyses, areas were determined for each subarea using U.S. Geological Survey (USGS) quadrangle maps at a scale of 1:24,000 (Reference 13). For each subarea, hydrographs were determined using NRCS methodology. Rainfall data for floods of the selected recurrence intervals were obtained using Weather Bureau Technical Paper No.40 (Reference 14). As part of the hydrologic analyses, a curve number was computed for the study area to reflect local land-use patterns.

Water-surface elevations for floods of the selected recurrence intervals were computed through the use of the USACE HEC-2 computer program (Reference 15). Starting water surface elevations for Horsepin and South Fork Horse Creeks were computed using the slope-area method.

All hydrologic analyses of Wilmott Creek were conducted in accordance with U.S. Water Resources Council Bulletin No. 17B, USACE Engineering Manual 1110-2-1417, and Engineering Manual 1110-2-1413 (References 6, 16, and 17). To develop discharge frequency information for the Wilmott Creek basin, the USACE HEC-HMS watershed runoff computer program was used (Reference 18). The USACE HEC-IFH computer program was used to route the inflow and outflow flood hydrographs for the ponding area along Wilmott Creek just upstream of the Jenks Levee (Reference 19).

Loss rates used in this analysis were based on historical storm calibrations of similar watersheds within the general vicinity. Initial loss rates of 1.30 inches and constant loss rates of 0.40 to 1.0 inches per hour were used. Flood hydrographs were routed with the Muskingum-Cunge method. Total rainfall depths and temporal distribution patterns were developed using Technical Paper No. 40 (Reference 14). A 15-minute computation interval was used in the HEC-HMS program. The 24-hour duration, 1-percent-annual-chance total rainfall depth used in this analysis is 8.95 inches.

The ponding area is drained by two 2,500 gallons-per-minute pumps rated for a head of 17.3 feet through three 110-foot long, 58-inch by 36-inch corrugated metal pipe arch culverts. The inlet invert of the three culverts is at elevation 604.75 feet, NGVD. The outlets for the gravity drains were field measured. The starting elevation for pumps 1 and 2 are 606.0 feet and 606.7 feet, respectively, and the stopping elevations are 605.2 feet and 605.9 feet, respectively. The ponding area discharges to Polecat Creek. The base flood elevation in the ponding area is 611.9 feet, NGVD.

The hydrologic analyses for each of the flooding sources in the Mingo Creek basin were performed using the USACE HEC-1 computer program (Reference 10). The basic model used was that developed by the USACE using 1992 basin conditions. The model was modified to include flood control facilities constructed for the Mingo Creek Local Protection Project using 1999 basin conditions (Reference 20). These facilities include numerous detention facilities and several miles of channel improvements, including bridges.

Discharges at selected locations within the Mingo Creek basin were developed by inputting the hypothetical rainfall data into a HEC-1 computer model and computing the resulting flood hydrographs for all subareas and combining points.

The hydrologic analyses for each of the following flooding sources, studied by Meshek and Associates, Inc., were performed using the USACE HEC-HMS computer program: Bird Creek Tributary 5A, Bixby Creek, Coal Creek Tributary A, Coal Creek Tributary B, Coal Creek (West Tulsa), Euchee Creek, Fry Ditch No. 1, Fry Ditch No. 1 Tributary, Fry Ditch No. 2, Fry Ditch No. 2 Tributary, Nichols Creek, Nickel Creek, Polecat Creek, Prattville Creek, Ranch Creek Tributary A, Ranch Creek Tributary B, Rolling Meadows Creek, Sand Creek, and Shell Creek. The synthetic unit hydrograph method used in the analyses was the SCS unit hydrograph method, with the following two exceptions: Fry Ditch No. 2 above 111th Street, which utilizes Snyder’s Unit Hydrograph method, incorporating a hydrologic model developed by the USACE, Tulsa District for use above the Shell Lake dam. The hydrologic model utilized equations developed from numerous studies within the District relating basin slope, stream length, and subarea shape to the hydrograph peaking time and the hydrograph’s shape. Rainfall data was developed using Technical Paper No. 40 (Reference 14).

The hydrologic analyses for each of the following flooding sources, studied by Watershed VI Alliance, were performed using the USACE HEC-HMS computer program: Blackjack Creek Tributary A, East Blackjack Creek Tributary, East Branch Haikey Creek, East Creek, Floral Haven Creek, Haikey Creek, Little Haikey Creek, Middle Branch Haikey Creek, Olive Creek, Park Grove Creek, Turtle Creek, West Branch Haikey Creek, and West Branch Haikey Creek Tributary. The hydrologic analyses for the Haikey Creek watershed were performed by the USACE, Tulsa District. The HEC-HMS model used the SCS curve number method for infiltration, the SCS Unit Hydrograph method for run-off transformation, and the modified Puls method for open channel routing. Rainfall data was developed using Water Resources Investigations Report 99-4232 (Reference 70).

The hydrologic analyses for the following flooding sources were studied by the USACE, Tulsa District: Anderson Creek, Anderson Creek Tributary, Anderson Creek Tributary A-1, Arkansas River, Berryhill Creek, Berryhill Creek Tributary, Bigheart Creek, Bird Creek, Blackjack Creek, Charley Creek, Cherry Creek (North Tulsa), Cherry Creek Tributary, Delaware Creek, Duck Creek, Duck Creek Tributary, Elm Creek, Fisher Creek, Fisher Creek Tributary, Franklin Creek, Harlow Creek, Hominy Creek, Horsepen Creek, Horsepen Creek Tributary 1, Horsepen Creek Tributary 2, Horsepen Creek Tributary 3, Horsepen Creek Tributary B, Horsepen Creek Tributary B Tributary, Horsepen Creek Tributary C, Little Sand Creek, Panther Creek, Posey Creek, Posey Creek North Tributary 1, Posey Creek South Tributary 1, Posey Creek South Tributary 2, Ranch Creek, Ranch Creek Tributary, Shady Grove Creek, Skalall Creek, Skalall Creek Tributary, Skunk Creek, Snake Creek, Snake Creek Tributary, and White Church Creek.

The hydrologic analysis for each of the flooding sources in the Broken Arrow Creek

Sequoyah Creek, Spunky Creek, Spunky Creek Tributary A, Spunky Creek Tributary B, Spunky Creek Tributary B-1, Spunky Creek Tributary G, and Unnamed Tributaries 1, 2, 3 and 4 to West Branch Broken Arrow Creek. The HEC-HMS model used the SCS curve number method for infiltration, the SCS Unit Hydrograph method for run-off transformation, and the modified Puls method for open channel routing. Rainfall data was developed using Water Resources Investigations Report 99- 4232. (Reference 70).

The hydrologic analysis for each of the flooding sources in the Joe Creek basin was performed using the USACE HEC-HMS version 3.5 computer program. The streams studied in detail in Joe Creek basin include Joe Creek upstream of East 56th Place, East Branch Joe Creek, East Branch Joe Creek Split Flow, West Branch Joe Creek, Little Joe Creek, North Fork Little Joe Creek and South Fork Little Joe Creek. The HEC-HMS model used the SCS curve number method for infiltration, the SCS Unit Hydrograph method for run-off transformation, and the Modified Puls method for open channel routing. Rainfall data was developed using Technical Paper No. 40, “Rainfall Frequency Atlas of the United States” and National Oceanic Atmospheric Administration (NOAA) Technical Memorandum NWS HYDRO-35.

The hydrologic analysis for each of the flooding sources in the Brookhollow Creek basin was performed using the USACE HEC-HMS version 4.2 computer program. Streams studied in detail include Brookhollow Creek, Brookhollow Creek Overflow, Brookhollow Creek Tributary, and Tributary to Brookhollow Creek Tributary. The HEC-HMS model used the SCS curve number method for infiltration, the SCS Unit Hydrograph method for run-off transformation, and the Modified Puls method for open channel routing. The limit of study was Brookhollow Creek at the confluence with Mingo Creek. Rainfall data was developed using Technical Paper No.40, “Rainfall Frequency Atlas of the United States” and National Oceanic and Atmospheric Administration (NOAA) Technical Memorandum NWS HYDRO-35.

The hydrologic analysis for each of the flooding sources in the Little Haikey Creek basin was performed using the USACE HEC-HMS version 5.0.5 computer program. Streams studied in detail include Little Haikey Creek. The HEC-HMS model used the SCS curve number method for infiltration, the SCS Unit Hydrograph method for run-off transformation, and the Modified Puls method for open channel routing. The limit of study was Little Haikey Creek at the confluence with Haikey Creek. Rainfall data was developed using Technical Paper No.40, “Rainfall Frequency Atlas of the United States” and National Oceanic and Atmospheric Administration (NOAA) Technical Memorandum NWS HYDRO-35.

Peak discharge-drainage area relationships for the streams studied by detailed methods are shown Table 3, “Summary of Discharges.”

Table 3: Summary of Discharges

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
ALSUMA CREEK					
At mouth	*	320	520	620	1,260
At 51st Street	*	630	1,220	1,510	2,300
ANDERSON CREEK					
At confluence with Fisher Creek	*	4,305	7,740	9,750	15,390
Just downstream of W. 41st Street	*	3,700	6,585	8,235	12,880
Approximately 1,000 feet downstream of W. 56th Street	*	3,210	5,710	7,140	11,170
Approximately 700 feet upstream of W. 56th Street	*	2,720	4,855	6,075	9,510
Approximately 1,850 feet upstream of W. 56th Street	*	1,840	3,235	4,060	6,385
ANDERSON CREEK TRIBUTARY					
At mouth	*	1,030	1,750	2,160	3,340
Approximately 5,300 feet upstream of 145th Street	*	1,840	3,235	4,060	6,385
ANDERSON CREEK TRIBUTARY A-1					
At mouth	*	245	415	510	785
ARKANSAS RIVER					
At mouth	23,090	90,000	155,000	205,000	490,000
AUDUBON CREEK					
At 90th East Avenue	*	2,420	4,370	5,270	7,900
Upstream of Interstate 44	*	2,080	3,750	4,550	6,790
BELL CREEK					
At 37th Street	*	1,510	2,610	3,130	4,670
At Broken Arrow Expressway	*	940	1,620	1,970	2,990

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
BELL CREEK TRIBUTARY					
At 41st Street	*	480	800	980	1,670
At 46th Street	*	240	440	620	970
BERRYHILL CREEK					
At mouth	*	4,502	7,776	9,655	14,988
Approximately 3,200 feet upstream of 21st Street	*	4,349	7,500	9,299	14,414
Approximately 1,600 feet downstream of 57th West Avenue	*	4,047	6,970	8,639	13,387
Upstream of confluence of Berryhill Creek Tributary	*	1,527	2,643	3,281	5,092
Approximately 1,200 feet downstream of convenience culvert near stadium	*	1,291	2,230	2,766	4,292
Approximately 100 feet downstream of convenience culvert near stadium	*	986	1,698	2,105	3,260
Approximately 3,500 feet upstream of 65th West Avenue	*	632	1,083	1,341	2,073
BERRYHILL CREEK TRIBUTARY					
At mouth	*	2,532	4,348	5,386	8,336
Approximately 500 feet upstream of 31st Street	*	2,219	3,805	4,712	7,290
Approximately 1,600 feet upstream of 31st Street	*	1,478	2,525	3,126	4,830
Approximately 450 feet downstream of 41st Street	*	973	1,666	2,063	3,191

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
BIGHEART CREEK					
At mouth	*	6,730	12,200	14,500	22,500
Approximately 300 feet upstream of Charles Page Boulevard	*	6,070	10,900	13,500	20,700
Just downstream of U.S. Highway 64	*	1,810	3,170	3,970	6,140
BIRD CREEK					
Approximately 1.5 miles downstream of U.S. Highway 266	*	27,800	49,500	62,700	98,600
Just downstream of U.S. Highway 169	*	22,900	39,700	50,400	97,600
Approximately 0.5 mile downstream of Atchison, Topeka and Sante Fe Railway	*	21,500	38,000	50,700	97,600
BIRD CREEK					
Approximately 0.6 mile downstream of 56th Street	*	21,100	38,100	50,800	99,400
BIRD CREEK TRIBUTARY 5A					
At mouth	*	1,658	2,274	2,492	2,855
At E. 5th Avenue South	*	1,972	2,493	2,688	3,006
At E. 76th Street North	*	2,192	3,037	3,249	4,007
At U.S. Highway 169	*	1,106	1,256	1,286	1,439
At N. 117th Avenue East	*	561	863	1,004	1,287
At E. 86th Street North	*	641	956	1,091	1,370
At N. 123rd Avenue East	*	337	502	578	841
Downstream of Pond 21	*	163	302	427	718
BIXBY CREEK					
At mouth	*	2,102	3,107	3,641	5,162
Approximately 1,700 feet upstream of mouth	*	1,751	2,590	3,022	4,258
Approximately 500 feet downstream of Mingo Road	*	1,678	2,499	2,914	3,992

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
BIXBY CREEK (Cont.)					
Approximately 1,000 feet downstream of Riverview Drive	*	1,625	2,425	2,828	3,799
Approximately 1,000 feet upstream of Riverview Drive	*	1,499	2,204	2,533	3,400
Approximately 1,000 feet upstream of Memorial Drive	*	660	952	1,078	1,447
Approximately 1,400 feet upstream of 151st Street	*	548	820	937	1,226
Approximately 3,100 feet upstream of 151st Street	*	257	374	427	555
BLACKJACK CREEK					
At mouth	*	3,760	6,800	8,610	13,700
Approximately 2,100 feet downstream of 132nd Street	*	3,310	5,880	7,380	11,600
At 126th Street North	*	2,146	3,801	4,703	6,993
Upstream of the confluence of Remington Tributary	*	1,799	3,161	3,868	5,607
At 122nd Street North	*	1,275	2,240	2,741	3,985
At 129th Avenue East	*	1,064	1,904	2,459	3,130
At 116th Street North	*	83	119	137	174
BLACKJACK CREEK TRIBUTARY A					
Upstream of the confluence with Blackjack Creek	1.43	1,972	2,709	3,056	3,905
Approximately 130 feet upstream of Railroad	1.26	2,098	2,787	3,140	4,008
Just upstream of confluence of Tributary to Blackjack Creek Tributary A	1.18	1,832	2,556	2,876	3,674

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
BROKEN ARROW CREEK					
Confluence with Arkansas River (mouth)	18.62	6,639	10,532	12,630	17,410
Approximately 3,700 feet downstream of East 131st Street South	17.83	6,650	10,479	12,561	17,354
Downstream of confluence with Broken Arrow Creek West Branch	17.61	6,637	10,458	12,542	17,347
Approximately 3,300 feet upstream of East 131st Street South	12.36	4,855	7,792	9,270	12,919
Approximately 1,300 feet upstream of East 121st Street South	11.62	4,897	7,730	9,217	12,788
Approximately 2,000 feet downstream of South 23rd Street	11.3	4,866	7,679	9,155	12,703
Approximately 1,000 feet upstream of South 23rd Street	10.94	4,856	7,666	9,132	12,663
Downstream of confluence with Broken Arrow Creek Tributary	10.13	4,688	7,411	8,851	12,318
Upstream of East 101st Street South	3.17	2,013	3,168	3,744	5,374
Downstream of Strip Mine	3.1	2,003	3,153	3,726	5,346
Upstream of Strip Mine	2.86	2,119	3,232	3,779	5,294
Approximately 3,000 feet downstream of South 23rd Street	2.52	1,988	3,041	3,580	4,913
At South 23rd Street	2.3	2,110	3,275	3,852	5,271
Approximately 700 feet upstream of East 91st Street South	1.88	1,891	2,870	3,362	4,546
Approximately 2,000 feet upstream of East 91st Street South	1.44	1,304	2,025	2,410	3,347
Approximately 5,000 feet downstream of East 81st Street South	1.06	962	1,527	1,785	2,488
At East 81st Street South	0.44	481	831	1,062	1,318
Approximately 3,000 feet upstream of East 81st Street South	0.18	312	492	584	805

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
BROOKHOLLOW CREEK					
At Mingo Road	*	2,100	2,660	4,170	8,740
At U.S. Highway 169	*	2,380	4,680	5,900	9,240
At 116th East Avenue	*	1,680	3,240	4,050	6,290
BROOKHOLLOW CREEK TRIBUTARY					
At mouth	*	830	1,610	2,010	3,300
CATFISH CREEK					
At mouth	*	580	1,050	1,290	1,940
Upstream of Tributary	*	750	1,360	1,670	2,650
CHARLEY CREEK					
At mouth	*	3,150	5,880	7,500	11,290
Upstream of confluence of Panther Creek	*	1,840	3,130	3,920	5,060
Approximately 1,000 feet upstream of U.S. Highway 75	*	1,960	3,470	4,330	6,760
CHERRY CREEK (NORTH TULSA)					
At mouth	*	2,540	4,510	5,670	8,930
Approximately 800 feet downstream of 146th Street North	*	2,050	3,600	4,490	7,010
Approximately 1,600 feet downstream of 136th Street North	*	1,450	2,530	3,140	4,880
Just downstream of 136th Street North	*	1,080	1,880	2,340	3,630
Approximately 1,700 feet downstream of Memorial Drive	*	450	790	980	1,510
CHERRY CREEK (NORTH TULSA) TRIBUTARY					
At mouth	*	420	720	890	1,380
Approximately 3,400 feet upstream of 136th Street North	*	100	170	210	330

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
CHERRY CREEK (NORTH TULSA) TRIBUTARY (Cont.)					
Approximately 4,600 feet upstream of 136th Street North	*	60	100	120	190
COAL CREEK (WEST TULSA)					
At mouth	*	9,091	12,241	13,797	18,013
Upstream of confluence of Coal Creek Tributary 1	*	9,028	12,541	14,002	17,937
Just downstream of 121st Street	*	7,222	9,895	10,946	13,714
Approximately 1,600 feet downstream of 126th Street	*	5,807	7,939	8,790	11,066
Approximately 1,300 feet downstream of 126th Street	*	4,885	6,635	7,323	9,116
Approximately 3,200 feet upstream of 131st Street	*	4,131	5,602	6,174	7,676
Approximately 1,400 feet downstream of 141st Street	*	3,153	4,239	4,822	6,015
Approximately 90 feet downstream of 141st Street	*	2,805	3,770	4,311	5,393
Just downstream of Main Street	*	2,435	3,284	3,722	4,674
Approximately 100 feet downstream of 151st Street	*	1,553	2,104	2,324	2,939
COAL CREEK TRIBUTARY A					
At mouth	*	869	1,178	1,301	1,649
COAL CREEK TRIBUTARY B					
At mouth	*	1,445	1,971	2,178	2,777
COOLEY CREEK					
At U.S. Highway 169	*	2,190	4,030	4,680	7,230
At Garnett Road	*	2,170	4,000	4,670	7,560

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
COOLEY CREEK (Cont.)					
At Interstate 244	*	1,080	1,990	2,370	4,360
DELAWARE CREEK					
At mouth	*	6,300	12,800	17,100	30,900
DOUGLAS CREEK					
At Mingo Road	*	2,590	4,530	5,640	8,710
At U.S. Highway 11	*	1,870	3,420	4,210	6,450
DUCK CREEK					
At mouth	*	11,900	22,900	33,400	65,500
Approximately 2,700 feet downstream of Memorial Drive	*	12,300	23,500	34,000	66,200
Approximately 2,800 feet upstream of Memorial Drive	*	13,200	24,600	33,600	64,300
Approximately 3,700 feet upstream of Sheridan Road	*	12,800	24,100	31,400	59,900
Approximately 1.9 miles upstream of Yale Avenue	*	6,600	12,900	17,200	37,000
Approximately 2.3 miles downstream of Peoria Avenue	*	6,400	12,500	18,400	35,100
Just upstream of confluence of Duck Creek Tributary 5	*	6,300	13,200	18,100	33,400
Just upstream of confluence of North Duck Creek	*	4,100	9,000	12,400	23,300
Just upstream of confluence of Duck Creek Tributary 6	*	5,800	10,700	14,100	24,700
Approximately 2,600 feet upstream of U.S. Highway 75	*	6,200	11,700	15,500	26,500

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
DUCK CREEK TRIBUTARY					
At mouth	*	2,750	5,350	6,900	11,300
Approximately 1,200 feet upstream of 201st Street	*	3,400	6,580	8,550	14,300
Approximately 2,500 feet upstream of U.S. Highway 75	*	3,540	6,600	8,430	13,610
Approximately 1.7 miles upstream of U.S. Highway 75	*	2,300	4,300	5,500	8,890
EAGLE CREEK					
At U.S. Highway 169	*	560	1,380	2,100	3,930
At Pine Street	*	740	1,370	1,700	2,610
EAST BLACKJACK CREEK TRIBUTARY					
Upstream of the confluence with East Creek	1.05	626	905	1,029	1,343
Approximately 0.2 mile downstream of Avenue D	1.01	613	889	1,013	1,321
Approximately 500 feet upstream of 136th Street	0.52	541	779	886	1,151
EAST BRANCH HAIKEY CREEK					
Upstream of the confluence with Haikey Creek	8.30	6,558	9,396	10,595	13,854
Approximately 100 feet upstream of the confluence of Middle Branch Haikey Creek	3.67	2,322	3,392	3,866	5,187
Approximately 100 feet downstream of Olive Street	3.48	2,264	3,307	3,761	5,041
Approximately 0.37 mile downstream of Chestnut Avenue	2.59	1,830	2,656	3,004	3,956
Approximately 150 feet downstream of Aspen Avenue	2.22	1,640	2,376	2,680	3,502

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
EAST BRANCH HAIKEY CREEK (Cont.)					
Approximately 0.38 mile upstream of Aspen Avenue	1.52	1,281	1,855	2,098	2,761
Just downstream of 91st Street	1.23	1,085	1,557	1,756	2,288
Approximately 0.48 mile upstream of 91st Street	0.95	898	1,241	1,383	1,770
Approximately 200 feet upstream of Elm Place	0.8	813	1,091	1,202	1,497
Approximately 430 feet upstream of Main Street	0.41	544	682	725	832
EAST CREEK					
At the county boundary	5.68	3,337	4,581	5,188	7,009
Approximately 0.2 mile upstream of the county boundary	5.24	3,267	4,501	5,093	6,995
Approximately 450 feet upstream of 146th Street	4.82	3,242	4,536	5,208	6,985
ELM CREEK					
At mouth	*	7,740	13,900	17,600	27,800
Approximately 2,200 feet upstream of 129th East Avenue	*	5,270	9,410	11,800	18,700
EUCHEE CREEK					
Upstream of the confluence with Arkansas River	*	3,823	6,274	7,042	10,206
At Willow Road	*	3,814	6,331	7,113	10,644
Upstream of the confluence of Euchee Creek Tributary L1	*	3,616	5,830	6,401	8,894
Upstream of the confluence of Euchee Creek Tributary R2	*	2,669	4,093	4,437	6,309
Upstream of the confluence of Euchee Creek Tributary R3	*	2,247	3,520	3,851	5,560

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
EUCHEE CREEK (Cont.)					
Upstream of the confluence of Euchee Creek Tributary L2	*	1,829	2,824	3,114	4,525
Upstream of the confluence of Euchee Creek Tributary L3	*	1,089	1,651	1,823	2,509
FISHER CREEK					
At mouth	*	6,216	12,209	15,959	27,317
Upstream of confluence of Anderson Creek	*	3,253	5,980	7,579	12,099
Approximately 0.7 mile downstream of W. 21st Street	*	3,509	6,165	7,726	12,135
Approximately 900 feet upstream of W. 21st Street	*	3,509	6,104	7,613	11,880
Approximately 100 feet downstream of Private Drive	*	3,385	5,874	7,307	11,373
Approximately 1,700 feet upstream of Private Drive	*	3,115	5,389	6,692	10,394
Upstream of confluence of Fisher Creek Tributary	*	2,582	4,438	5,497	8,511
Approximately 1,900 feet upstream of W. 32nd Street	*	1,538	2,650	3,284	5,088
Approximately 600 feet downstream of W. 41st Street	*	1,070	1,832	2,268	3,507
FISHER CREEK TRIBUTARY					
At mouth	*	1,047	1,791	2,217	3,429
FLORAL HAVEN CREEK					
Upstream of confluence with Haikey Creek	0.72	835	1,167	1,305	1,666
Approximately 450 feet upstream of 71st Street	0.66	808	1,125	1,261	1,607
Just downstream of Missouri-Kansas-Texas Railroad	0.3	444	605	675	844

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
FORD CREEK					
At Garnett Road	*	2,370	3,200	3,660	4,510
At 129th East Avenue	*	1,580	2,160	2,450	3,140
FRANKLIN CREEK					
At mouth	*	2,160	3,620	4,400	6,420
Approximately 300 feet downstream of Middle Park culvert	*	1,795	3,000	3,640	5,435
Approximately 500 feet upstream of Park Road	*	1,560	2,700	3,260	4,850
Approximately 200 feet downstream of U.S. Highway 64	*	1,400	2,400	2,935	4,350
Approximately 800 feet upstream of U.S. Highway 64	*	1,180	2,015	2,490	3,850
Approximately 200 feet upstream of 8th Street	*	980	1,665	2,055	3,170
Approximately 1.2 miles upstream of 11th Street	*	600	1,010	1,250	1,920
FRY DITCH NO. 1					
At mouth	*	1,776	2,722	3,175	5,054
Approximately 600 feet downstream of Memorial Drive	*	1,714	2,628	3,075	4,999
Just downstream of Memorial Drive	*	1,438	2,238	2,704	4,343
Approximately 2,800 feet upstream of Memorial Drive	*	1,420	2,220	2,682	4,300
Downstream of confluence of Fry Ditch No. 1 Tributary	*	1,308	2,079	2,547	4,042
Upstream of confluence of Fry Ditch No. 1 Tributary	*	1,208	1,956	2,428	3,792
Approximately 1,200 feet upstream of 111th Street	*	782	1,319	1,548	2,305

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
FRY DITCH NO. 1 (Cont.)					
Approximately 500 feet downstream of 121st Street	*	822	1,231	1,625	2,991
Approximately 1,400 feet downstream of 116th Street	*	397	723	1,048	2,065
FRY DITCH NO. 2					
At mouth	*	6,143	8,448	9,443	13,719
Upstream of confluence of Fry Ditch No. 1	*	5,184	7,028	7,734	9,528
Approximately 500 feet downstream of 121st Street	*	4,654	6,241	6,844	8,596
Just upstream of 121st Street	*	4,096	5,470	5,963	8,260
Approximately 1,400 feet upstream of 121st Street	*	4,033	5,370	5,855	8,224
Downstream of confluence of Fry Ditch No. 2 Tributary	*	3,909	5,151	5,617	8,150
Upstream of confluence of Fry Ditch No. 2 Tributary	*	3,847	5,065	5,460	7,656
Approximately 1,700 feet downstream of 111th Street	*	3,772	4,949	5,381	7,648
Approximately 600 feet downstream of 111th Street	*	53	82	97	131
Approximately 100 feet downstream of 111th Street	*	3,680	4,789	5,163	7,582
FULTON CREEK					
At 93rd East Avenue	*	950	1,710	2,090	3,110
At 38th Street	*	810	1,460	1,800	2,690
HAIKEY CREEK					
Approximately 50 feet upstream of 111th Street	18.85	10,514	16,286	18,787	25,420

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
HAIKEY CREEK (Cont.)					
Approximately 0.62 mile upstream of 111th Street	17.71	12,197	17,936	20,254	27,192
Just downstream of New Orleans Street	17.17	13,067	18,745	21,232	27,906
Approximately 0.33 mile upstream of New Orleans Street	17.10	12,840	18,417	20,847	27,404
Approximately 650 feet downstream of the confluence of East Branch Haikey Creek	16.22	12,632	18,148	20,509	26,936
Approximately 1,300 feet upstream of the confluence of East Branch Haikey Creek	7.86	5,861	8,410	9,525	12,589
Approximately 150 feet upstream of the confluence of Olive Creek	6.24	4,792	6,995	7,930	10,402
Approximately 180 feet upstream of Houston Street	5.91	4,673	6,854	7,752	10,086
Approximately 100 feet upstream of the confluence of West Branch Haikey Creek	2.82	2,164	3,214	3,639	4,681
Approximately 200 feet upstream of the confluence of Floral Haven Creek	1.86	1,217	1,868	2,106	2,680
Approximately 170 feet upstream of 71st Street	1.82	1,204	1,849	2,083	2,651
Approximately 0.47 mile upstream of 71st Street	1.33	910	1,304	1,451	1,860
Approximately 40 feet downstream of Olive Street	1.25	899	1,261	1,405	1,800
Approximately 40 feet downstream of Railroad	1.08	876	1,203	1,348	1,700
Approximately 70 feet downstream of North Hemlock Circle	0.65	261	370	414	777

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
HARLOW CREEK					
At mouth	*	4,280	7,720	9,710	14,700
Upstream of confluence of Harlow Creek Tributary	*	2,890	5,110	6,380	9,710
Approximately 150 feet downstream of Edison Street	*	2,660	4,700	5,850	8,960
HOMINY CREEK					
At mouth	*	9,108	18,342	22,719	34,374
HORSEPEN CREEK					
At mouth	*	10,400	20,000	25,700	38,000
Approximately 700 feet downstream of 129th East Avenue	*	8,270	15,000	18,900	29,800
Upstream of confluence of Cherry Creek (North Tulsa)	*	5,660	10,500	13,300	21,100
Upstream of confluence of Horsepen Creek Tributary 3	*	4,360	7,750	9,720	15,300
Upstream of confluence of Horsepen Creek Tributary 4	*	3,390	6,010	7,520	11,800
Upstream of confluence of Horsepen Creek Tributary 5	*	1,770	3,120	3,900	6,090
Upstream of confluence of Horsepen Creek Tributary B	*	870	1,530	1,910	2,980
Approximately 1,800 feet downstream of Highway 20	*	480	850	1,060	1,660
Approximately 600 feet downstream of Sheridan Road	*	270	470	590	920
Approximately 2,400 feet upstream of Sheridan Road	*	200	360	450	700

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
HORSEPEN CREEK TRIBUTARY 2					
At mouth	*	750	1,300	1,610	4,040
Approximately 2,300 feet upstream of 166th Street	*	250	430	530	810
Approximately 1,000 feet downstream of Private Drive	*	125	215	265	405
Approximately 150 feet downstream of Private Drive	*	43	73	90	138
HORSEPEN CREEK TRIBUTARY 3					
At mouth	*	1,650	2,910	3,640	5,700
Approximately 0.9 mile upstream of Sheridan Road	*	1,170	2,070	2,590	4,040
HORSEPEN CREEK TRIBUTARY B					
At mouth	*	740	1,300	1,620	2,540
Approximately 1,500 feet upstream of mouth	*	390	680	850	1,330
HORSEPEN CREEK TRIBUTARY B TRIBUTARY					
At mouth	*	350	620	770	1,210
HORSEPEN CREEK TRIBUTARY C					
At mouth	*	240	420	530	820
Just downstream of U.S. Highway 20	*	170	300	380	590
HORSEPIN CREEK					
At confluence with South Fork Horse Creek	4.20	2,949	4,413	5,205	7,000
Approximately 980 feet downstream of Southern Pacific Railroad	0.94	1,134	1,664	1,947	2,600
Approximately 380 feet downstream of Southern Pacific Railroad	0.80	1,054	1,524	1,776	2,300

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
JONES CREEK					
At mouth	*	1,480	2,470	2,940	4,850
At 69th East Avenue	*	770	1,120	1,290	2,900
LITTLE CREEK					
At U.S. Highway 169	*	1,050	2,170	2,720	4,220
At 38th Street	*	710	1,320	1,630	2,510
LITTLE HAIKEY CREEK					
Approximately 0.45 mile upstream of the confluence with Haikey Creek	6.17	3,711	5,442	6,249	8,815
Just upstream of 111th Street	5.93	3,685	5,400	6,198	8,776
Approximately 0.5 mile upstream of 111th Street	5.43	3,610	5,298	6,075	8,624
LITTLE SAND CREEK					
At mouth	*	523	566	611	667
Approximately 700 feet upstream of Wekiwa Road	*	444	452	460	466
Approximately 300 feet upstream of Keystone Expressway	*	1,143	1,715	2,296	3,028
Approximately 1,700 feet upstream of Keystone Expressway	*	846	1,269	1,679	2,220
Approximately 3,300 feet upstream of Keystone Expressway	*	767	1,143	1,520	2,007
MIDDLE BRANCH HAIKEY CREEK					
Upstream of the confluence with East Branch Haikey Creek	4.76	4,227	6,001	6,723	8,664
Approximately 0.57 mile upstream of Washington Street	4.41	4,095	5,821	6,509	8,364
Approximately 300 feet upstream of the confluence of Turtle Creek	3.37	3,318	4,665	5,185	6,560

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
MIDDLE BRANCH HAIKEY CREEK (Cont.)					
Approximately 560 feet upstream of Houston Street	3.14	3,306	4,653	5,171	6,532
Approximately 320 feet upstream of the confluence of Middle Branch Haikey Creek Tributary	2.73	2,956	4,109	4,551	5,722
Approximately 350 feet upstream of Aspen Avenue	2.69	2,947	4,094	4,534	5,693
Approximately 200 feet upstream of confluence of Park Grove Creek	1.04	1,223	1,568	1,709	2,084
Approximately 570 feet upstream of Broadway Street	0.98	1,196	1,530	1666	2,029
Approximately 170 feet upstream of Missouri-Kansas-Texas Railroad	0.77	1,053	1,350	1,477	1,794
MILL CREEK					
At 89th East Avenue	*	3,490	5,230	5,910	8,600
At Memorial Drive	*	1,870	2,430	2,530	4,850
MINGO CREEK					
At Apache Street	*	17,840	31,190	36,100	47,850
Downstream of Mill Creek	*	15,230	22,870	25,150	30,510
Downstream of Audubon Creek	*	10,940	18,600	22,180	31,460
At 31st Street	*	7,210	13,060	16,300	23,370
Downstream of Alsuma Creek	*	3,880	7,030	8,500	13,590
At 61st Street	*	1,530	2,130	2,410	3,450
Upstream of Glen Eagles	*	1,250	2,290	2,800	4,760
NICHOLS CREEK					
At mouth	*	869	1,124	1,234	1,501
Approximately 200 feet upstream of 25th Avenue West	*	476	630	696	853

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
NICKEL CREEK					
At mouth	*	5,338	7,861	9,078	9,078
Just downstream of 33rd West Avenue	*	4,013	5,501	6,196	8,036
OLIVE CREEK					
Upstream of the confluence with Haikey Creek	1.16	1,231	1,773	2,001	2,614
Approximately 340 feet downstream of Houston Street	0.94	1,044	1,497	1,690	2,199
Approximately 850 feet upstream of Olive Street	0.64	774	1,104	1,247	1,611
Approximately 80 feet upstream of Elgin Street	0.44	581	825	933	1,198
PANTHER CREEK					
At mouth	*	1,580	2,890	3,660	5,850
Approximately 600 feet downstream of U.S. Highway 75	*	1,300	2,280	2,840	4,410
PARK GROVE CREEK					
Upstream of the confluence with Middle Branch Haikey Creek	1.53	1,789	2,523	2,834	3,624
Approximately 0.37 mile downstream of Missouri-Kansas-Texas Railroad	0.97	1,291	1,805	2,027	2,563
Approximately 200 feet downstream of Missouri-Kansas-Texas Railroad	0.9	1,21	1,703	1,912	2,409
POLECAT CREEK					
At mouth	*	34,183	48,573	55,671	74,526
Upstream of confluence of Coal Creek (West Tulsa)	*	34,052	48,426	55,346	74,003
Approximately 1,200 feet downstream of 33rd West Avenue	*	33,755	47,985	54,661	72,957

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
POSEY CREEK					
At mouth	*	5,690	10,175	13,075	21,403
Approximately 1,400 feet upstream of Yale Place	*	6,128	10,914	13,681	21,781
Upstream of the confluence of Posey Creek Tributary 2	*	3,799	6,824	8,571	13,941
Upstream of the confluence of Posey Creek Tributary 3	*	2,975	5,329	6,694	10,529
Approximately 1,200 feet upstream of Harvard Avenue	*	2,586	4,597	5,769	9,067
Approximately 1,000 feet downstream of Lewis Avenue	*	2,354	4,185	5,193	8,121
Approximately 1,700 feet downstream of Peoria Avenue	*	1,670	2,915	3,626	5,644
Approximately 200 feet downstream of Peoria Avenue	*	1,406	2,443	3,035	4,717
POSEY CREEK NORTH TRIBUTARY 1					
At mouth	*	1,049	1,814	2,251	3,493
Approximately 1,100 feet upstream of Harvard Avenue	*	839	1,443	1,788	2,772
Approximately 1,200 feet downstream of 19th Street	*	686	1,178	1,457	2,255
Approximately 900 feet downstream of 136th Place	*	443	755	934	1,883
Approximately 100 feet downstream of Lewis Avenue	*	95	306	552	1,148
POSEY CREEK SOUTH TRIBUTARY 1					
At mouth	*	1,038	1,797	2,230	3,462
Approximately 900 feet downstream of 151st Street	*	553	946	1,171	1,811

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
POSEY CREEK SOUTH TRIBUTARY 2					
At mouth	*	2,346	4,116	5,144	8,043
Approximately 400 feet downstream of U.S. Highway 97	*	2,269	4,016	5,004	7,797
Approximately 2,500 feet upstream of U.S. Highway 97	*	1,090	1,905	2,370	3,687
PRATTVILLE CREEK					
Upstream of the confluence with the Arkansas River	*	3,119	5,167	5,958	8,324
At 41st Street	*	2,465	3,813	4,176	5,573
At U.S. Highway 97	*	1,591	2,471	2,726	3,617
At 51st Street	*	430	692	780	1,108
QUARRY CREEK					
At U.S. Highway 169	*	3,119	5,167	5,958	8,324
At 129th East Avenue	*	2,465	3,813	4,176	5,573
RANCH CREEK					
At mouth	*	5,000	10,100	13,300	23,300
Just downstream of Mingo Road	*	6,870	14,100	18,400	31,000
Upstream of confluence of Bird Creek Tributary 5B	*	5,450	10,300	13,100	21,000
Upstream of confluence of Ranch Creek Tributary A	*	5,480	9,580	11,900	18,600
Upstream of confluence of Ranch Creek Tributary B	*	3,130	5,410	6,710	10,400
Approximately 3,300 feet downstream of 106th Street	*	2,090	3,580	4,430	6,860
Approximately 150 feet upstream of 106th Street	*	1,550	2,640	3,270	5,050

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
RANCH CREEK (Cont.)					
Approximately 600 feet downstream of 114th Street	*	1,240	2,110	2,620	4,040
Approximately 200 feet downstream of Mingo Road	*	670	1,120	1,390	2,130
Approximately 150 feet downstream of 116th Street	*	570	950	1,180	1,800
RANCH CREEK TRIBUTARY					
At mouth	*	2,490	4,850	6,320	11,050
Approximately 3,100 feet downstream of Atchison, Topeka, and Sante Fe Railway	*	2,340	4,220	5,320	8,420
Approximately 600 feet downstream of Atchison, Topeka, and Sante Fe Railway	*	2,310	4,010	4,980	7,730
Approximately 300 feet downstream of 76th Street	*	1,840	3,180	3,940	6,110
Approximately 500 feet downstream of 86th Street	*	1,130	1,930	2,380	3,690
Approximately 700 feet downstream of Sheridan Road	*	460	780	970	1,490
RANCH CREEK TRIBUTARY A					
At railroad bridge	*	842	1,344	1,620	2,225
At 86th Street North	*	1,036	1,724	2,019	2,493
Upstream of the confluence of Fairways Tributary	*	*	*	1,235	*
At 91st Street North	*	*	*	1,216	*
At Birch Street	*	*	*	773	*
At Garnett Road	*	*	*	538	*
At 96th Street North	*	*	*	486	*

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
RANCH CREEK TRIBUTARY B					
At mouth	*	1,767	2,809	3,403	4,657
Just downstream of Atchison, Topeka, and Sante Fe Railway	*	1,728	2,739	3,324	4,508
Approximately 1,600 feet upstream of Atchison, Topeka, and Sante Fe Railway	*	1,697	2,676	3,258	4,381
Approximately 700 feet upstream of Mingo Road	*	1,662	2,676	3,258	4,381
Approximately 2,600 feet upstream of Mingo Road	*	1,446	2,226	2,751	3,683
Approximately 1,000 feet downstream of 106th Street	*	948	1,395	1,656	2,184
Approximately 400 feet upstream of 106th Street	*	665	958	1,117	1,528
Approximately 1,000 feet upstream of 106th Street	*	564	842	969	1,214
Approximately 900 feet downstream of Garnett Road	*	460	691	796	1,017
ROLLING MEADOWS CREEK					
At mouth	*	812	1,685	2,141	3,512
Just upstream of 145th Street	*	786	1,636	2,100	3,456
Approximately 200 feet upstream of 25th Avenue West	*	695	1,454	1,896	3,180
SAND CREEK					
At mouth	*	812	1,685	2,141	3,512
Approximately 100 feet downstream of Wekiwa Road	*	796	1,636	2,100	3,456
Approximately 2,700 feet upstream of U.S. Highway 64	*	695	1,454	1,896	3,180

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
SEQUOYAH CREEK					
Upstream of South Ash Court	0.38	939	1,372	1,585	2,088
Approximately 600 feet downstream of South Ash Court	0.54	1,066	1,558	1,797	2,390
SHADY GOVE CREEK					
At mouth	*	1,690	2,910	3,490	5,410
SHELL CREEK					
Upstream of the confluence with the Arkansas River	*	4,320	6,012	7,157	10,315
At U.S. Highway 64	*	4,315	6,005	7,149	10,303
Upstream of the confluence of Shell Creek Tributary L1	*	4,237	5,888	7,013	10,093
Upstream of the confluence of Shell Creek Tributary L2	*	4,105	5,687	6,799	9,765
Downstream of Shell Lake	*	4,010	5,542	6,637	9,512
SKALALL CREEK					
At mouth	*	6,100	11,100	14,000	22,300
Approximately 3,800 feet upstream of mouth	*	5,000	10,000	11,500	18,200
SKALALL CREEK TRIBUTARY					
At mouth	*	1,920	3,400	4,240	6,640
Approximately 300 feet downstream of 176th Street	*	1,310	4,430	2,860	4,460
SKUNK CREEK					
At mouth	*	2,820	4,970	6,210	9,710
Approximately 1,700 feet downstream of Peoria Avenue	*	2,520	4,430	5,520	8,610
Approximately 1.6 miles upstream of Peoria Avenue	*	980	1,710	2,130	3,310

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
SNAKE CREEK					
At mouth	*	11,010	22,410	30,360	58,530
Approximately 4,700 feet upstream of mouth	*	16,740	34,520	47,800	90,450
Approximately 1 mile upstream of U.S. Highway 64	*	16,620	34,250	47,200	88,920
Approximately 4,000 feet downstream of Mingo Road	*	16,520	34,000	46,700	87,880
Approximately 1,800 feet downstream of Mingo Road	*	18,540	36310	50,930	98,540
Approximately 3,800 feet upstream of Mingo Road	*	7,190	14,630	20,470	39,440
Approximately 3,800 feet upstream of 201st Street		7,290	14,910	20,960	40,260
Approximately 2,300 feet upstream of 201st Street	*	9,190	19,550	26,450	46,580
SOUTHPARK CREEK					
At mouth	*	370	660	1,050	1,850
Upstream of Dam	*	690	1,300	1,550	2,280
SUGAR CREEK					
At U.S. Highway 169	*	1,100	1,970	2,390	3,600
At 41st Street (downstream)	*	650	1,130	1,330	1,840
TUPELO CREEK					
At Mingo Road	*	1,750	2,800	3,380	5,070
At U.S. Highway 169	*	1,630	2,500	2,910	4,920
At Interstate 44	*	1,430	1,950	2,160	4,530
At 16th Street	*	1,120	2,070	2,570	3,980
TUPELO CREEK TRIBUTARY A					
At 119th East Avenue	*	300	530	640	1,020
At 24th East Avenue	*	640	1,160	1,420	2,160

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
TUPELO CREEK TRIBUTARY C					
At Interstate 44	*	280	520	630	970
At 127th East Avenue	*	210	380	440	670
TURTLE CREEK					
Upstream of the confluence with Middle Branch Haikey Creek	0.9	901	1,311	1,499	1,964
Approximately 150 feet upstream of Aspen Avenue	0.72	733	1,066	1,212	1,595
Approximately 280 feet upstream of Knoxville Street	0.4	440	636	723	946
UNNAMED TRIBUTARY 1 TO WEST BRANCH BROKEN ARROW CREEK					
Confluence with Broken Arrow Creek West Branch (Mouth)	0.43	1,040	1,520	1,751	2,253
UNNAMED TRIBUTARY 2 TO WEST BRANCH BROKEN ARROW CREEK					
Approximately 800 feet upstream of South 9th Street	0.23	339	503	575	735
Confluence with Broken Arrow Creek West Branch (Mouth)	0.07	120	193	230	321
UNNAMED TRIBUTARY 3 TO WEST BRANCH BROKEN ARROW CREEK					
Confluence with Broken Arrow Creek West Branch (Mouth)	0.32	313	539	671	789

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
UNNAMED TRIBUTARY 4 TO WEST BRANCH BROKEN ARROW CREEK					
Approximately 400 feet upstream of East 91st Street South	0.27	352	619	755	1,122
Confluence with Broken Arrow Creek West Branch (Mouth)	0.16	234	426	533	787
WEST BRANCH BROKEN ARROW CREEK					
Confluence with Broken Arrow Creek (Mouth)	4.85	2,660	4,101	4,963	6,985
Approximately 4,600 feet upstream of confluence with Broken Arrow Creek	4.30	2,622	4,100	4,941	6,905
Approximately 1,700 feet downstream East 121st Street South	3.98	2,644	4,170	5,016	6,966
Approximately 1,000 upstream of East 121st Street South	3.76	2,669	4,189	5,031	6,949
Approximately 5,400 feet upstream of East 121st Street South	3.28	2,623	4,090	4,906	6,762
Approximately 700 feet downstream of South 9th Street	2.87	2,575	3,933	4,705	6,499
Approximately 600 feet upstream of South 9th Street	2.67	2,429	3,716	4,455	6,135
Upstream of confluence with Unnamed Tributary 1	2.13	2,113	3,272	3,959	5,427
Downstream of confluence with Sequoyah Creek	1.90	1,986	3,113	3,776	5,195
Downstream of confluence with Unnamed Tributary 2	1.32	1,245	2,056	2,481	3,233
Upstream of confluence with Unnamed Tributary 2	1.09	1,176	1,940	2,342	3,051

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
WEST BRANCH BROKEN ARROW CREEK (Cont.)					
Upstream of confluence with Unnamed Tributary 3	0.68	933	1,492	1,785	2,431
Upstream of confluence with Unnamed Tributary 4	0.26	583	886	1,041	1,411
WEST BRANCH HAIKEY CREEK					
Upstream of the confluence with Haikey Creek	3.04	2,656	3,762	4,237	5,479
Approximately 1,136 feet downstream of confluence of West Branch Haikey Creek Tributary	2.73	2,648	3,748	4,223	5,460
Approximately 320 feet upstream of confluence of West Branch Haikey Creek Tributary	1.61	1,507	2,146	2,414	3,132
Approximately 372 feet upstream of Garrett Road	1.49	1,411	2,003	2,253	2,919
Approximately 100 feet upstream of Mingo Valley Expressway	1.04	1,008	1,425	1,610	2,077
WEST BRANCH HAIKEY CREEK TRIBUTARY					
Upstream of the confluence with West Branch Haikey Creek	1.09	944	1,339	1,511	1,945
WHITE CHURCH CREEK					
At mouth	*	1,350	2,342	2,896	4,460
Approximately 1,000 feet downstream of Garnett Road	*	1,039	1,798	2,223	3,422
Approximately 1,500 feet downstream of 126th Street	*	787	1,337	1,648	2,527

Table 3: Summary of Discharges, Continued

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-percent	2-percent	1-percent	0.2-percent
WHITE CHURCH CREEK (Cont.)					
Approximately 350 feet downstream of Olive Street	*	679	1,139	1,400	2,141
Approximately 1,700 feet upstream of 121st Street	*	571	940	1,152	1,754

* Data Not Available

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals. Users should be aware that flood elevations shown on the Flood Insurance Rate Map (FIRM) represent rounded whole-foot elevations and may not exactly reflect the elevations shown on the Flood Profiles or in the Floodway Data tables in the FIS report. Flood elevations shown on the FIRM are primarily intended for flood insurance rating purposes. For construction and/or floodplain management purposes, users are cautioned to use the flood elevation data presented in this FIS in conjunction with the data shown on the FIRM.

Water-surface elevations of floods of the selected recurrence intervals were computed using the USACE HEC-2 computer program (Reference 15). Flood profiles were drawn showing computed water-surface elevations for floods of the selected recurrence intervals.

Cross section data for the streams in the City of Bixby study area were obtained from topographic maps at a scale of 1:4,800, with a contour interval of 2 feet and supplemental contour intervals of 1 foot, furnished by the TMAPC, and dated 1976 (Reference 22). Bridge and road plans were used for some of the cross sections, while other bridge cross sections and geometry were field measured (Reference 23).

For the previous study in Broken Arrow, cross sections for the streams studied by detailed methods through the City of Broken Arrow were obtained by field surveys and aerial photogrammetry. These sections were extended to the overbank areas using topographic maps at a scale of 1:2,400, with a contour interval of 2 feet, supplemented with a contour interval of 1 foot (Reference 24). Some bridges were field surveyed to obtain structural geometry, while available bridge and road plans were used for others (Reference 23).

For the 2014 restudy of Broken Arrow Creek watershed, the cross section and roughness data has been extracted using the GIS based tools developed by the Corps of Engineers (HEC-GeoRAS). The base terrain data was developed from a new aerial LIDAR survey, performed for this project by Dewberry & Davis, of the detailed study areas. Water surface elevations for the following streams were computed through the use of the USACE HEC-RAS Version 4.1 computer program: Broken Arrow Creek, West Branch Broken Arrow Creek, Unnamed Tributary 1 to West Branch Broken Arrow Creek, Unnamed Tributary 2 to West Branch Broken Arrow Creek, Unnamed Tributary 3 to West Branch Broken Arrow Creek, Unnamed Tributary 4 to West Branch Broken Arrow Creek and Sequoyah Creek. Starting water-surface elevations for all streams were calculated using normal depth. Roughness coefficients (Manning’s “n” values) used in hydraulic computations for the streams studied by detailed methods were assigned on the basis of field inspection supplemented by aerial photography of floodplain areas. Channel and overbank “n” values for the streams studied by detailed methods are shown in Table 4, "Manning's "n" Values." Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles. For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the FIRM. The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the Flood Profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail. Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals. Users should be aware that flood elevations shown on the FIRM represent rounded whole-foot elevations and may not exactly reflect the elevations shown on the Flood Profiles or in the Floodway Data tables in the FIS report. Flood elevations shown on the FIRM are primarily intended for flood insurance rating 66 purposes. For construction and/or floodplain management purposes, users are cautioned to use the flood elevation data presented in this FIS in conjunction with the data shown on the FIRM. In the original Flood Insurance Study for the City of Glenpool, cross sections for the backwater analyses of each stream studied in detail were obtained by photogrammetric surveys from aerial photographs (Reference 25). Bridge plans were used for some of the cross sections, while other bridges were field measured (Reference 23). In the restudy, cross sections for the backwater computations were developed from aerial photogrammetric maps at a scale of 1:200, with a contour interval of 2 feet (Reference 26). Cross sections at bridges and bridge geometry were field surveyed and supplemented with as-built drawings, when appropriate. A field reconnaissance was made in February 1990 to obtain bridge data, channel and overbank roughness coefficients (Manning's "n" values), and flood elevations of past events. In the original study for the City of Owasso, cross section data used in the backwater analyses of each stream studied by detailed methods were obtained by photogrammetric surveys flown in March 1977 (Reference 27). Bridge data were based on field surveys and bridge plans (Reference 23). In the restudy for the City of Owasso, cross section data for the backwater analyses for each stream studied by detailed methods were developed from aerial photogrammetric maps at a scale of 1:200, with a contour interval of 2 feet (Reference 28). The aerial maps were flown in April 1989. Cross section data at bridges and bridge geometry were field surveyed and supplemented with as-built drawings of the bridges when appropriate. In the original study for the City of Sand Springs, cross sections used for the backwater analyses of each stream studied in detail were obtained by photogrammetric surveys flown in March 1977 (Reference 27). Some cross sections were adjusted for ineffective flow areas, such as borrow pits behind levees, and occasionally at the approach section upstream or downstream of a bridge. It was found that for the lower 3 miles of Fisher Creek, the 1-percent-annual-chance flood overtops the embankment of the St. Louis San Francisco Railway and spills over onto Fisher Bottom adjacent to the Arkansas River. Therefore, for that reach, the 1-percent-annual-chance water-surface profile was estimated to be approximately 0.5 foot above the embankment grade. Because flows with a 1-percent-annual-chance and greater return period spill over the railroad and the lower 3.5 miles of Fisher Creek are submerged by the 0.2-percent-annual-chance flood of the Arkansas River, no independent 0.2-percent-annual-chance flood was computed for that area. Backwater models used for the City of Sand Springs restudy were a combination of existing models and new data. The backwater model for Euchee Creek developed for the original study went from the mouth to Gaging Station No. 11500. Additional cross sections were developed from 1990 topography to extend the model to Gaging Station No. 16560 (Reference 29). The model from the original Flood Insurance Study for the City of Sand Springs, developed for Anderson Creek, was used for the restudy, with additional cross sections added for improved modeling of certain reaches. The additional cross sections were developed from 1977 topography (Reference 27). For West Bigheart Creek, in the City of Sand Springs, only the 1 -percent-annual-chance water-surface profile was developed. A backwater model was developed using the model developed for a Bigheart Creek feasibility study. This model extended from the mouth of West Bigheart Creek through Gaging Station No. 5188. Additional cross sections were developed using 1977 topography to extend the model through Gaging Station No. 18867 (Reference 27). Cross sections of each of the stream channels and valleys studied by detailed methods through the City of Tulsa were obtained by field surveys and aerial photogrammetry. These sections were supplemented by data taken from topographic maps at a scale of 1:2,400, with a contour interval 67 of 2 feet (Reference 25). Bridge and road plans were used for some cross sections (Reference 23). Other bridge cross sections and geometry were field measured. The hydraulic features of Little Haikey Creek Tributary have changed due to channel modifications and the construction of the South 77th Avenue bridge. Updated cross sections of the revised channel area were field surveyed. These sections were supplemented by data taken from topographic maps at a scale of 1:600, with a contour interval of 1 foot (Reference 30). Bridge geometry was field measured. For the Mingo Creek basin, the hydraulic analyses were performed to incorporate the effects of channelization, culverts, bridges, and 28 detention ponds, which include off-channel, flow-through, and impoundment detention. Roughness coefficients (Manning's "n") used in the study were obtained based on field reconnaissance and photographs of the area. Numerous studies in the area were also used to obtain "n" values. The "n" values used for Mingo Creek and its tributaries range from 0.015 in the channel to 0.04-0.150 in the overbanks. Water-surface elevations within the Mingo Creek basin were computed using the USACE HEC-2 computer program (Reference 15). In conjunction with the revised hydraulic analyses, the 1-percent-annual-chance floodway was recomputed for each of the restudied flooding sources, with the exception of Alsuma and Audubon Creeks. Because Alsuma and Audubon Creeks flow within underground conduits, the determination of floodways was not applicable for these flooding sources. Cross sections of each of the stream channels studied in detail throughout the unincorporated areas of Tulsa County were obtained by aerial photogrammetry and field surveys. Those sections were supplemented by topographic maps at a scale of 1:2,400, with a contour interval of 2 feet (Reference 25). In the restudy, cross sections for the backwater computations for Nichols and Rolling Meadows Creeks were developed from aerial photogrammetric maps at scales of 1:200 and 1:400, with contour intervals of 2 feet (Reference 26). Bridge and road plans were used for some of the cross sections, while other bridge cross sections and bridge geometry were field measured and supplemented with as- built drawings, when appropriate (Reference 23). For Sand and Little Sand Creeks, USGS 7.5-minute quadrangle maps at a scale of 1:24,000 were used for the hydrologic analyses (Reference 13). Two sources of mapping at a scale of 1:2,400 were used in the 1979 Flood Insurance Study for the City of Sand Springs (flight date March 1977) as necessary to supplement the existing backwater models. In addition, topographic maps at a scale 1:2,400 were obtained for the upper reaches of Sand Creek from aerial photography dated April 1990 (Reference 29). Water-surface profiles were developed for the 10-, 2-, 1-, and 0.2-percent-annual-chance floods on Sand Creek using the USACE HEC-2 computer program (Reference 15). Bridges and culverts were measured, and Manning's "n" values were estimated during a field survey of the stream. Starting water-surface elevations were obtained using the slope-area method. The effects of the Arkansas River on the stream studied are depicted as flat pools on the profile plots. The water surface elevations for the Arkansas River were taken from the 1979 Flood Insurance Study for the City of Sand Springs (Reference 12). Future sedimentation of Keystone Lake may result in higher discharges for the Arkansas River than those used in the 1979 Flood Insurance Study. Backwater models used on Sand Creek were a combination of existing models and new data. For Sand Creek, a model was developed for Stream Stations 4040 through 9030 in the 1979 Flood Insurance Study. The model was expanded to cover Stream Stations 328 through 19840. Cross sections below Station 4040 were developed from the 1977 topographic maps, while cross sections above Station 9030 were developed using the 1990 topography. The flat-pool backwater effect from the Arkansas River is depicted on the plotted profile for Sand Creek. Due to the flow phenomenon in the lower reach of Sand Creek, floodway computations were begun at Station 4040. 68 Water surface profiles for the 10-, 2-, 1-, and 0.2-percent-annual-chance floods were computed for Wilmott Creek using the USACE HEC-RAS computer program (Reference 31). Aerial photogrammetric mapping for Wilmott Creek was developed by Aerial Photo Service, Inc. in Tulsa, Oklahoma, in March 1977 (Reference 25). The 1977 aerial photography was supplemented with aerial photography flown by Aerial Photo Services, Inc., in March 1997 (Reference 32). The Wilmott Creek watershed was delineated using the March 1977 mapping and the U.S. Geological Survey's 7.5-minute quadrangle entitled "Jenks, Oklahoma" (Reference 13). Cross sections for the HEC-RAS model were developed using the March 1977 aerial topographic information. Bridge geometry was determined by field measurement in February 1998. Roughness coefficients for the channel and overbank areas were determined by a field inspection of the Wilmott Creek study area on November 1997 and February 1998. Cross section data used in the backwater analyses for the remainder of streams throughout the County studied by detailed methods were obtained by photogrammetric surveys flown in March 1977 (Reference 27). Roughness coefficients (Manning's "n" values) were based on field reconnaissance and photographs of the area. High-water marks for recent floods were used to verify the width values. Channel and overbank "n" values for the streams studied by detailed methods are shown in Table 4, "Manning's "n" Values." Starting water-surface elevations on tributaries to the Arkansas River and Bird Creek were determined by the normal-depth method. For tributary streams, the starting water-surface elevations were obtained by the slope-area method or from backwater effects from the main flooding source. The higher of the two elevations was used. If the backwater from the Arkansas River or Bird Creek was higher, it was considered the controlling elevation. Starting elevations for some streams were based on coincident peak flooding occurring on the streams into which the tributaries flow. Starting water-surface elevations for the Coal Creek tributaries were based on coincident flooding of Coal Creek. Starting water-surface elevations for Nichols and Rolling Meadows Creeks were determined using the slope-area method. Starting water-surface elevations on Polecat and Posey Creeks were determined using the slope-area method. The higher of these creeks or the Arkansas River elevation was used near the mouth of these streams. Starting water-surface elevations for Bird Creek Tributary 5A were based on the existing profile at U.S. Route 169. Starting water surface elevations for North and South Fork Little Joe Creeks were determined using critical-depth calculations. The effects of the Arkansas River on its tributaries are depicted as flat pools on the profile plots. Water-surface elevations for the Arkansas River were taken from the original study for the City of Sand Springs. The future sedimentation of Keystone Lake may result in higher discharges for the Arkansas River. No model existed for Euchee Creek, so a new model was developed from the mouth at Gaging Station No. 16560 of Euchee Creek to Gaging Station No. 4840. The backwater effect of the Arkansas River on Euchee Creek is shown as a flat pool on the plotted profile. 69 The backwater model for Fisher Creek developed in the original study was used in this restudy with only minor revisions. However, the split flow option of HEC-2 was used to model the loss of flow that occurs with the overtopping of the railroad fill in the left overbank (Reference 15). The backwater effect of Bigheart Creek is shown as a flat pool on the plotted profile. No backwater analysis was done on Hominy Creek because flooding on the lower end is controlled by Bird Creek. Flood profiles for Adams Creek and its tributaries were determined in a report prepared by the USACE, Tulsa District (Reference 33). To determine ponding elevations at the lower end of Wilmott Creek behind the levee, it was assumed no releases would be made through the flap-gate culverts due to high water on Polecat Creek. Discharge through the pumps would be minor; therefore, the entire runoff within the levee was assumed to be stored. Stream profiles on Wilmott Creek were computed using the slope-area method. The final profile is based on the higher of the ponding elevation or stream profile. The 0.2-percent-annual-chance profile of the Arkansas River controls within the levee. Several tributaries to Bird Creek and other streams in northern Tulsa County were studied by approximate methods. The 1-percent-annual-chance flood boundary was delineated by using topographic maps with a contour interval of 2 feet and the best information available. Profiles were not prepared for those streams. For the streams studied by approximate methods through the City of Broken Arrow, the extent of the 1-percent-annual-chance flood was determined using historic flooding information. For the following streams, water-surface elevations were computed through the use of HEC-RAS, Version 2.2 (Reference 31): Bird Creek, Charley Creek, Cherry Creek (North Tulsa), Cherry Creek Tributary, Delaware Creek, Duck Creek, Duck Creek Tributary, Elm Creek, Hominy Creek, Horsepen Creek, Horsepen Creek Tributary 1, Horsepen Creek Tributary 2, Horsepen Creek Tributary 3, Horsepen Creek Tributary B, Horsepen Creek Tributary C, Panther Creek, Posey Creek, Ranch Creek, Ranch Creek Tributary, Skalall Creek, Skalall Creek Tributary, Skunk Creek, and Snake Creek. Water-surface elevations for the following streams were computed through the use of HEC- RAS, Version 3.1.1 (Reference 31): Anderson Creek, Anderson Creek Tributary, Anderson Creek Tributary A-1, Berryhill Creek, Berryhill Creek Tributary, Bigheart Creek, Euchee Creek, Fisher Creek, Fisher Creek Tributary, Franklin Creek, Harlow Creek, Little Sand Creek, Shady Grove Creek, Shell Creek, and White Church Creek. Water-surface elevations for the following streams were computer through the use of HEC- RAS, Version 3.1.2 (Reference 31): Blackjack Creek Tributary A, East Blackjack Creek Tributary, East Branch Haikey Creek, East Creek, Floral Haven Creek, Haikey Creek, Little Haikey Creek, Middle Branch Haikey Creek, Olive Creek, Park Grove Creek, Turtle Creek, West Branch Haikey Creek, and West Branch Haikey Creek Tributary. Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross-section locations are also shown on the FIRM. The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail. For the September 30, 2016 physical map revision, for the Polecat-Snake and Lower Verdigris Watersheds the discharges for the 10-, 2-, 1-, and 0.2-percent-annual chance recurrence intervals for all detailed studied streams were determined using a HEC-HMS 70 model which utilized the NRCS (SCS) curve number method for infiltration, the SCS Unit Hydrograph method for run-off transformation, and the modified Puls method for open channel routing. Rainfall data was developed using Water Resources Investigation Report 99-4232. (Reference 34)

For the 2016 study of the Joe Creek watershed, the cross section and roughness data has been extracted using the GIS based tools developed by the Corps of Engineers (HEC-GeoRAS). The base terrain data was developed from 2010 topographic data performed by Aerial Data Service, of the detailed study areas. Water surface elevations for the following streams were computed through the use of the USACE HEC-RAS Version 4.1.0 computer program: Joe Creek (upstream of East 56th Street), East Branch Joe Creek, East Branch Joe Creek Spilt Flow, West Branch Joe Creek, Little Joe Creek, North Fork Little Joe Creek and South Fork Little Joe Creek. Joe Creek model used a known water surface elevation at Station E as the starting water-surface elevation. Roughness coefficients (Manning's "n" values) used in the hydraulic computations for the stream studied by detailed methods were assigned on the basis of field inspection supplemented by aerial photography of floodplain areas. Channel and overbank "n" values for the streams studied by detailed methods are shown in Table 4, Manning's "n" Values.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles. For stream segments for which a floodway was computed (Section 4.2), selected cross-section locations are also shown on the FIRM.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the Flood Profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals. Users should be aware that flood elevations shown on the FIRM represent rounded whole-foot elevations and may not exactly reflect the elevations shown on the Flood Profiles or in the Floodway Data tables in the FIS report. Flood elevations shown on the FIRM are primarily intended for flood insurance rating purposes. For construction and/or floodplain management purposes, users are cautioned to use the flood elevation data presented in this FIS in conjunction with the data shown on the FIRM.

In the original Flood Insurance Study for the City of Glenpool, cross sections for the backwater analyses of each stream studied in detail were obtained by photogrammetric surveys from aerial photographs (Reference 25). Bridge plans were used for some of the cross sections, while other bridges were field measured (Reference 23). In the restudy, cross sections for the backwater computations were developed from aerial photogrammetric maps at a scale of 1:200, with a contour interval of 2 feet (Reference 26). Cross sections at bridges and bridge geometry were field surveyed and supplemented with as-built drawings, when appropriate. A field reconnaissance was made in February 1990 to obtain bridge data, channel and overbank roughness coefficients (Manning's "n" values), and flood elevations of past events.

In the original study for the City of Owasso, cross section data used in the backwater analyses of each stream studied by detailed methods were obtained by photogrammetric surveys flown in March 1977 (Reference 27). Bridge data were based on field surveys and bridge plans (Reference 23).

In the restudy for the City of Owasso, cross section data for the backwater analyses for each stream studied by detailed methods were developed from aerial photogrammetric maps at a scale of 1:200, with a contour interval of 2 feet (Reference 28). The aerial maps were flown in April 1989. Cross section data at bridges and bridge geometry were field surveyed and supplemented with as-built drawings of the bridges when appropriate.

In the original study for the City of Sand Springs, cross sections used for the backwater analyses of each stream studied in detail were obtained by photogrammetric surveys flown in March 1977 (Reference 27). Some cross sections were adjusted for ineffective flow areas, such as borrow pits behind levees, and occasionally at the approach section upstream or downstream of a bridge. It was found that for the lower 3 miles of Fisher Creek, the 1-percent-annual-chance flood overtops the embankment of the St. Louis San Francisco Railway and spills over onto Fisher Bottom adjacent to the Arkansas River. Therefore, for that reach, the 1-percent-annual-chance water- surface profile was estimated to be approximately 0.5 foot above the embankment grade. Because flows with a 1-percent-annual-chance and greater return period spill over the railroad and the lower 3.5 miles of Fisher Creek are submerged by the 0.2-percent-annual-chance flood of the Arkansas River, no independent 0.2-percent-annual-chance flood was computed for that area.

Backwater models used for the City of Sand Springs restudy were a combination of existing models and new data. The backwater model for Euchee Creek developed for the original study went from the mouth to Gaging Station No. 11500. Additional cross sections were developed from 1990 topography to extend the model to Gaging Station No. 16560 (Reference 29).

The model from the original Flood Insurance Study for the City of Sand Springs, developed for Anderson Creek, was used for the restudy, with additional cross sections added for improved modeling of certain reaches. The additional cross sections were developed from 1977 topography (Reference 27).

For West Bigheart Creek, in the City of Sand Springs, only the 1-percent-annual-chance water-surface profile was developed. A backwater model was developed using the model developed for a Bigheart Creek feasibility study. This model extended from the mouth of West Bigheart Creek through Gaging Station No. 5188. Additional cross sections were developed using 1977 topography to extend the model through Gaging Station No. 18867 (Reference 27).

Cross sections of each of the stream channels and valleys studied by detailed methods through the City of Tulsa were obtained by field surveys and aerial photogrammetry. These sections were supplemented by data taken from topographic maps at a scale of 1:2,400, with a contour interval of 2 feet (Reference 25). Bridge and road plans were used for some cross sections (Reference 23). Other bridge cross sections and geometry were field measured. The hydraulic features of Little Haikey Creek Tributary have changed due to channel modifications and the construction of the South 77th Avenue bridge. Updated cross sections of the revised channel area were field surveyed.

These sections were supplemented by data taken from topographic maps at a scale of 1:600, with a contour interval of 1 foot (Reference 30). Bridge geometry was field measured.

For the Mingo Creek basin, the hydraulic analyses were performed to incorporate the effects of channelization, culverts, bridges, and 28 detention ponds, which include off-channel, flow-through, and impoundment detention. Roughness coefficients (Manning's "n") used in the study were obtained based on field reconnaissance and photographs of the area. Numerous studies in the area were also used to obtain "n" values. The "n" values used for Mingo Creek and its tributaries range from 0.015 in the channel to 0.04-0.150 in the overbanks.

Water-surface elevations within the Mingo Creek basin were computed using the USACE HEC-2 computer program (Reference 15). In conjunction with the revised hydraulic analyses, the 1-percent-annual-chance floodway was recomputed for each of the restudied flooding sources, with the exception of Alsuma and Audubon Creeks. Because Alsuma and Audubon Creeks flow within underground conduits, the determination of floodways was not applicable for these flooding sources.

Cross sections of each of the stream channels studied in detail throughout the unincorporated areas of Tulsa County were obtained by aerial photogrammetry and field surveys. Those sections were supplemented by topographic maps at a scale of 1:2,400, with a contour interval of 2 feet (Reference 25). In the restudy, cross sections for the backwater computations for Nichols and Rolling Meadows Creeks were developed from aerial photogrammetric maps at scales of 1:200 and 1:400, with contour intervals of 2 feet (Reference 26). Bridge and road plans were used for some of the cross sections, while other bridge cross sections and bridge geometry were field measured and supplemented with as-built drawings, when appropriate (Reference 23).

For Sand and Little Sand Creeks, USGS 7.5-minute quadrangle maps at a scale of 1:24,000 were used for the hydrologic analyses (Reference 13). Two sources of mapping at a scale of 1:2,400 were used in the 1979 Flood Insurance Study for the City of Sand Springs (flight date March 1977) as necessary to supplement the existing backwater models. In addition, topographic maps at a scale 1:2,400 were obtained for the upper reaches of Sand Creek from aerial photography dated April 1990 (Reference 29).

Water-surface profiles were developed for the 10-, 2-, 1-, and 0.2-percent-annual-chance floods on Sand Creek using the USACE HEC-2 computer program (Reference 15). Bridges and culverts were measured and Manning's "n" values were estimated during a field survey of the stream. Starting water-surface elevations were obtained using the slope-area method. The effects of the Arkansas River on the stream studied are depicted as flat pools on the profile plots. The water-surface elevations for the Arkansas River were taken from the 1979 Flood Insurance Study for the City of Sand Springs (Reference 12). Future sedimentation of Keystone Lake may result in higher discharges for the Arkansas River than those used in the 1979 Flood Insurance Study.

Backwater models used on Sand Creek were a combination of existing models and new data. For Sand Creek, a model was developed for Stream Stations 4040 through 9030 in the

1979Flood Insurance Study. The model was expanded to cover Stream Stations 328 through19840. Cross sections below Station 4040 were developed from the 1977 topographic maps, while cross sections above Station 9030 were developed using the 1990 topography. The flat- pool backwater effect from the Arkansas River is depicted on the plotted profile for Sand Creek. Due to the flow phenomenon in the lower reach of Sand Creek, floodway computations were begun at Station 4040.

Water surface profiles for the 10-, 2-, 1-, and 0.2-percent-annual-chance floods were computed for Wilmott Creek using the USACE HEC-RAS computer program (Reference 31).

Aerial photogrammetric mapping for Wilmott Creek was developed by Aerial Photo Service, Inc. in Tulsa, Oklahoma, in March 1977 (Reference 25). The 1977 aerial photography was supplemented with aerial photography flown by Aerial Photo Services, Inc., in March 1997 (Reference 32). The Wilmott Creek watershed was delineated using the March 1977 mapping and the U.S. Geological Survey's 7.5-minute quadrangle entitled "Jenks, Oklahoma" (Reference 13).

Cross sections for the HEC-RAS model were developed using the March 1977 aerial topographic information. Bridge geometry was determined by field measurement in February1998. Roughness coefficients for the channel and overbank areas were determined by a field inspection of the Wilmott Creek study area on November 1997 and February 1998.

Cross section data used in the backwater analyses for the remainder of streams throughout the County studied by detailed methods were obtained by photogrammetric surveys flown in March 1977 (Reference 27).

Roughness coefficients (Manning's "n" values) were based on field reconnaissance and photographs of the area. High-water marks for recent floods were used to verify the width values. Channel and overbank "n" values for the streams studied by detailed methods are shown in Table 4, "Manning's "n" Values."

Starting water-surface elevations on tributaries to the Arkansas River and Bird Creek were determined by the normal-depth method. For tributary streams, the starting water-surface elevations were obtained by the slope-area method or from backwater effects from the main flooding source. The higher of the two elevations was used. If the backwater from the Arkansas River or Bird Creek was higher, it was considered the controlling elevation. Starting elevations for some streams were based on coincident peak flooding occurring on the streams into which the tributaries flow.

Starting water-surface elevations for the Coal Creek tributaries were based on coincident flooding of Coal Creek.

Starting water-surface elevations for Nichols and Rolling Meadows Creeks were determined using the slope-area method.

Starting water-surface elevations on Polecat and Posey Creeks were determined using the slope-area method. The higher of these creeks or the Arkansas River elevation was used near the mouth of these streams.

Starting water-surface elevations for Bird Creek Tributary 5A were based on the existing profile at U.S. Route 169.

Starting water-surface elevations for North and South Fork Little Joe Creeks were determined using critical-depth calculations.

The effects of the Arkansas River on its tributaries are depicted as flat pools on the profile plots. Water-surface elevations for the Arkansas River were taken from the original study for the City of Sand Springs. The future sedimentation of Keystone Lake may result in higher discharges for the Arkansas River.

No model existed for Euchee Creek so a new model was developed from the mouth at Gaging Station No. 16560 of Euchee Creek to Gaging Station No. 4840. The backwater effect of the Arkansas River on Euchee Creek is shown as a flat pool on the plotted profile.

The backwater model for Fisher Creek developed in the original study was used in this restudy with only minor revisions. However, the split-flow option of HEC-2 was used to model the loss of flow that occurs with the overtopping of the railroad fill in the left overbank (Reference 15).

The backwater effect of Bigheart Creek is shown as a flat pool on the plotted profile.

No backwater analysis was done on Hominy Creek because flooding on the lower end is controlled by Bird Creek.

Flood profiles for Adams Creek and its tributaries were determined in a report prepared by the USACE, Tulsa District (Reference 33).

To determine ponding elevations at the lower end of Wilmott Creek behind the levee, it was assumed no releases would be made through the flap-gate culverts due to high water on Polecat Creek. Discharge through the pumps would be minor; therefore, the entire runoff within the levee was assumed to be stored. Stream profiles on Wilmott Creek were computed using the slope-area method. The final profile is based on the higher of the ponding elevation or stream profile. The 0.2-percent-annual-chance profile of the Arkansas River controls within the levee.

Several tributaries to Bird Creek and other streams in northern Tulsa County were studied by approximate methods. The 1-percent-annual-chance flood boundary was delineated by using topographic maps with a contour interval of 2 feet and the best information available. Profiles were not prepared for those streams.

For the streams studied by approximate methods through the City of Broken Arrow, the extent of the 1-percent-annual-chance flood was determined using historic flooding information.

For the following streams, water-surface elevations were computed through the use of HEC-RAS, Version 2.2 (Reference 31): Bird Creek, Charley Creek, Cherry Creek (North Tulsa), Cherry Creek Tributary, Delaware Creek, Duck Creek, Duck Creek Tributary, Elm Creek, Hominy Creek, Horsepen Creek, Horsepen Creek Tributary 1, Horsepen Creek Tributary 2, Horsepen Creek Tributary 3, Horsepen Creek Tributary B, Horsepen Creek Tributary C, Panther Creek, Posey Creek, Ranch Creek, Ranch Creek Tributary, Skalall Creek, Skalall Creek Tributary, Skunk Creek, and Snake Creek.

Water-surface elevations for the following streams were computed through the use of HEC-RAS, Version 3.1.1 (Reference 31): Anderson Creek, Anderson Creek Tributary, Anderson Creek Tributary A-1, Berryhill Creek, Berryhill Creek Tributary, Bigheart Creek, Euchee Creek, Fisher Creek, Fisher Creek Tributary, Franklin Creek, Harlow Creek, Little Sand

Creek, Shady Grove Creek, Shell Creek, and White Church Creek.

Water-surface elevations for the following streams were computer through the use of HEC-RAS, Version 3.1.2 (Reference 31): Blackjack Creek Tributary A, East Blackjack Creek Tributary, East Branch Haikey Creek, East Creek, Floral Haven Creek, Haikey Creek, Little Haikey Creek, Middle Branch Haikey Creek, Olive Creek, Park Grove Creek, Turtle Creek, West Branch Haikey Creek, and West Branch Haikey Creek Tributary.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross-section locations are also shown on the FIRM.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

For the September 30, 2016 physical map revision, for the Polecat-Snake and Lower Verdigris Watersheds the discharges for the 10-, 2-, 1-, and 0.2-percent-annual chance recurrence intervals for all detailed studied streams were determined using a HEC-HMS 70 model which utilized the NRCS (SCS) curve number method for infiltration, the SCS Unit Hydrograph method for run-off transformation, and the modified Puls method for open channel routing. Rainfall data was developed using Water Resources Investigation Report.

For the May 2, 2019 physical map revision, water surface elevations for the following streams were computed through the use of the USACE HEC-RAS version 4.1 computer program: Joe Creek upstream of Lettered Cross section F, Little Joe Creek, North Fork Little Joe Creek, South Fork Little Joe Creek, East Branch Joe Creek, East Branch Joe Creek Split Flow, and West Branch Joe Creek.

The existing storm sewer capacities were analyzed using StormCAD Version 8i. These capacities were deducted from the flow rates at appropriate locations to estimate the overland flow used in HEC-RAS model.

Known water surface elevation (637.9 feet at lettered cross section E for a 100-year storm) was used as the boundary condition. Roughness coefficients (Manning's “n” values) used in the hydraulic computations for the streams studied by detailed methods were assigned on the basis of field inspection supplemented by aerial photography of floodplain areas. Channel and overbank “n” values for the streams studied by detailed methods are shown in Table 4, “Manning’s “n” Values.”

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross-section locations are also shown on the FIRM.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the Flood Profiles (Exhibit 1) are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

For the 2017 study of Brookhollow Creek Watershed, the cross sections and roughness data was extracted using the GIS based tools developed by the Corps of Engineers (HEC-GeoRAS). Digital terrain model (DTM) updates were performed by Aerial Data Service, Inc. (ADS) in conjunction with the City of Tulsa to create a digital terrain model of the study area. The LiDAR terrain model and two foot contours generated from the DTM data were utilized in the hydrologic and hydraulic modeling process. Water surface elevations for the following streams were computed through the use of the USACE HEC-RAS version 5.0.3 computer program: Brookhollow Creek, Brookhollow Creek Overflow, Brookhollow Creek Tributary, and Tributary to Brookhollow Creek Tributary.

The existing storm sewer capacities were analyzed using StormCAD Version 8i. These capacities were deducted from the flow rates at appropriate locations to estimate the overland flow used in HEC-RAS model.

Normal depth was used as the boundary condition for starting water surface elevations. Roughness coefficients (Manning's "n" values) used in the hydraulic computations for the streams studied by detailed methods were assigned on the basis of field inspection supplemented by aerial photography of floodplain areas. Channel and overbank "n" values for the streams studied by detailed methods are shown in Table 4, "Manning's "n" Values."

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross-section locations are also shown on the FIRM.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the Flood Profiles (Exhibit 1) are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

For the 2019 study of Little Haikey Creek Watershed, the cross sections and roughness data was extracted using the GIS based tools developed by the Corps of Engineers (HEC-GeoRAS). Digital terrain model (DTM) updates were performed by Aerial Data Service, Inc. (ADS) in conjunction with the City of Tulsa to create a digital terrain model of the study area. The LiDAR terrain model and two foot contours generated from the DTM data were utilized in the hydrologic and hydraulic modeling process. Water surface elevations for Little Haikey Creek were computed through the use of the USACE HEC-RAS version 5.0.5 computer program.

The existing storm sewer capacities were analyzed using StormCAD Version 8i. These capacities were deducted from the flow rates at appropriate locations to estimate the overland flow used in HEC-RAS model.

Normal depth was used as the boundary condition for starting water surface elevations. Roughness coefficients (Manning's "n" values) used in the hydraulic computations for the streams studied by detailed methods were assigned on the basis of field inspection supplemented by aerial photography of floodplain areas. Channel and overbank "n" values for the streams studied by detailed methods are shown in Table 4, "Manning's "n" Values."

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross-section locations are also shown on the FIRM.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the Flood Profiles (Exhibit 1) are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

Table 4. Manning's "n" Values

Flooding Source	Roughness Coefficients Channel	Roughness Coefficients Overbanks
Adams Creek	0.055 - 0.060	0.040 - 0.065
Adams Creek Tributary E	0.065	0.050
Anderson Creek	0.060	0.090 - 0.140
Anderson Creek Tributary	0.055 - 0.065	0.090 - 0.120
Anderson Creek Tributary A-1	0.055	0.090
Arkansas River	0.015 - 0.055	0.050 - 0.150
Berryhill Creek	0.035 - 0.050	0.045 - 0.070
Berryhill Creek Tributary	0.040	0.060
Bigheart Creek	0.030 - 0.055	0.035 - 0.120
Bird Creek	0.029 - 0.080	0.035 - 0.120
Bird Creek Tributary 5A	0.010 - 0.070	0.020 - 0.150
Bixby Creek	0.030 - 0.050	0.030 - 0.100
Blackjack Creek	0.040 - 0.100	0.040 - 0.110
Blackjack Creek Tributary A	0.045	0.050 - 0.100
Broken Arrow Creek	0.035 - 0.045	0.050 - 0.080
Brookhollow Creek	0.015 - 0.070	0.015 - 0.200
Brookhollow Creek Tributary	0.030 - 0.070	0.015 - 0.500
Caney River	0.045	0.080
Charley River	0.050 - 0.070	0.070 - 0.120
Cherry Creek (North Tulsa)	0.035 - 0.090	0.040 - 0.120
Cherry Creek Tributary	0.035 - 0.080	0.040 - 0.100
Cherry Creek (West Tulsa)	0.015 - 0.050	0.060 - 0.100
Coal Creek (North Tulsa)	0.020 - 0.080	0.040 - 0.080
Coal Creek Tributary	0.050 - 0.100	0.060 - 0.150
Coal Creek (West Tulsa)	0.035 - 0.060	0.030 - 0.100
Coal Creek Tributary A	0.050 - 0.070	0.050 - 0.060
Coal Creek Tributary B	0.050 - 0.060	0.050 - 0.080
Covington Creek	0.050 - 0.090	0.060 - 0.110
Covington Creek Tributary	0.050 - 0.080	0.060 - 0.100
Delaware Creek	0.050 - 0.060	0.060 - 0.073
Delaware Creek Tributary	0.050 - 0.100	0.050 - 0.100
Dirty Butter Creek	0.040 - 0.100	0.035 - 0.180

Table 4. Manning's "n" Values, Continued

Flooding Source	Roughness Coefficients Channel	Overbanks
Dirty Butter Creek Tributary	0.040 - 0.100	0.035 - 0.180
Diversion Channel (DC)	*	*
Duck Creek	0.045	0.060 - 0.090
Duck Creek Tributary	0.040 - 0.045	0.060 - 0.080
East Blackjack Creek Tributary	0.045	0.050 - 0.100
East Branch Haikey Creek	0.025 - 0.055	0.050 - 0.120
East Branch Joe Creek	0.013 - 0.150	0.020 - 0.400
East Branch Joe Creek Split Flow	0.013 - 0.040	0.030 - 0.400
East Creek	0.045	0.050 - 0.150
Elm Creek	0.035 - 0.060	0.030 - 0.075
Euchee Creek	0.050 - 0.060	0.050 - 0.150
Fisher Creek	0.040 - 0.060	0.040 - 0.120
Fisher Creek Tributary	0.040 - 0.050	0.040 - 0.100
Flood Relief Channel (FRC)	*	*
Flat Rock Creek	0.035 - 0.080	0.040 - 0.200
Flat Rock Creek Tributary A	0.035 - 0.080	0.040 - 0.200
Floral Haven Creek	0.035 - 0.055	0.035 - 0.100
Fox Meadow Tributary	*	*
Franklin Creek	0.050 - 0.075	0.060 - 0.150
Fred Creek	0.040 - 0.080	0.050 - 0.150
Fry Ditch No. 1	0.035 - 0.060	0.035 - 0.080
Fry Ditch No. 2	0.035 - 0.050	0.035 - 0.080
Hager Creek	0.045 - 0.100	0.050 - 0.100
Haikey Creek	0.040 - 0.060	0.030 - 0.150
Harlow Creek	0.025 - 0.035	0.030 - 0.080
Hominy Creek	0.050 - 0.060	0.070 - 0.090
Horsepen Creek	0.030 - 0.080	0.035 - 0.120
Horsepen Creek Tributary 1	0.030 - 0.060	0.035 - 0.080
Horsepen Creek Tributary 2	0.035 - 0.060	0.035 - 0.070
Horsepen Creek Tributary 3	0.040 - 0.060	0.040 - 0.070
Horsepen Creek Tributary B	0.040	0.040
Horsepen Creek Tributary B Tributary	0.040	0.040

Table 4. Manning's "n" Values, Continued

	Roughness Coefficients	
Flooding Source	Channel	Overbanks
Horsepen Creek Tributary C	0.040	0.045
Horsepin Creek	0.055 - 0.060	0.090 - 0.100
Interior Drainage	*	*
Joe Creek	0.013 - 0.050	0.020 - 0.400
Little Haikey Creek	0.015 - 0.100	0.013 - 0.100
Little Joe Creek	0.013 - 0.040	0.013 - 0.400
Little Sand Creek	0.035	0.040 - 0.070
Lower Fred Creek	0.060 - 0.090	0.070 - 0.110
Middle Branch Haikey Creek	0.033 - 0.058	0.035 - 0.100
Mingo Creek	0.015 - 0.150	0.040 - 0.150
Mooser Creek	0.060 - 0.070	0.060 - 0.150
Nichols Creek	0.050 - 0.060	0.060 - 0.100
Nickel Creek	0.050 - 0.060	0.040 - 0.100
North Fork Little Joe Creek	0.013 - 0.040	0.013 - 0.400
Olive Creek	0.045 - 0.055	0.015 - 0.120
Panther Creek	0.040 - 0.070	0.045 - 0.100
Park Grove Creek	0.050 - 0.065	0.015 - 0.100
Polecat Creek	0.040 - 0.050	0.040 - 0.090
Posey Creek	0.040 - 0.070	0.045 - 0.120
Posey Creek North Tributary 1	0.026 - 0.046	0.040 - 0.100
Posey Creek South Tributary 1	0.035 - 0.045	0.045 - 0.055
Posey Creek South Tributary 2	0.035 - 0.045	0.035 - 0.055
Posey Creek Tributary	0.045 - 0.100	0.050 - 0.120
Prattville Creek	0.030 - 0.060	0.040 - 0.150
Ranch Creek	0.030 - 0.060	0.050 - 0.080
Ranch Creek Tributary	0.027 - 0.080	0.050 - 0.100
Ranch Creek Tributary A	0.010 - 0.080	0.035 - 0.100
Ranch Creek Tributary B	0.040 - 0.060	0.040 - 0.100
Rolling Meadows Creek	0.040 - 0.070	0.040 - 0.100
Sand Creek	0.040 - 0.050	0.032 - 0.100
Sequoyah Creek	0.035 - 0.045	0.050 - 0.080

Table 4. Manning's "n" Values, Continued

Flooding Source	Roughness Coefficients Channel	Overbanks
Shady Grove Creek	0.035 - 0.055	0.040 - 0.100
Shell Creek	0.055 - 0.072	0.090 - 0.110
Skalall Creek	0.045 - 0.050	0.040 - 0.055
Skalall Creek Tributary	0.040 - 0.050	0.045 - 0.060
Skunk Creek	0.060 - 0.070	0.070 - 0.100
Snake Creek	0.055 - 0.060	0.045 - 0.055
Snake Creek Tributary	0.050 - 0.100	0.040 - 0.090
South Fork Horse Creek	0.050 - 0.060	0.065 - 0.100
South Fork Little Joe Creek	0.013 - 0.065	0.020 - 0.065
Spunky Creek	0.030 - 0.080	0.015 - 0.100
Spunky Creek Tributary A	0.015 - 0.080	0.015 - 0.100
Spunky Creek Tributary B	0.030 - 0.080	0.015 - 0.100
Spunky Creek Tributary B-1	0.030 - 0.080	0.015 - 0.100
Spunky Creek Tributary G	0.030 - 0.045	0.015 - 0.100
Tributary to Brookhollow Creek Tributary	0.013 - 0.070	0.015 - 0.200
Turtle Creek	0.033 - 0.050	0.035 - 0.100
Unnamed Tributary 1 to West Branch Broken Arrow Creek	0.025 - 0.060	0.055 - 0.090
Unnamed Tributary 2 to West Branch Broken Arrow Creek	0.025 - 0.060	0.055 - 0.090
Unnamed Tributary 3 to West Branch Broken Arrow Creek	0.025 - 0.060	0.055 - 0.090
Unnamed Tributary 4 to West Branch Broken Arrow Creek	0.025 - 0.060	0.055 - 0.090
Vensel Creek	0.012 - 0.045	0.040 - 0.080
Vensel Creek South	0.050	0.040 - 0.080
Vensel Creek Tributary D	0.015	0.060
Vensel Creek Tributary H	0.015 - 0.025	0.040 - 0.050
West Bigheart Creek	0.035 - 0.060	0.040 - 0.100
West Branch Broken Arrow Creek	0.035 - 0.045	0.050 - 0.080
West Branch Haikey Creek	0.040	0.015 - 0.100
West Branch Haikey Creek Tributary	0.050	0.060 - 0.100
West Branch Joe Creek	0.013 - 0.150	0.013 - 0.400
White Church Creek	0.017 - 0.060	0.030 - 0.070
Wilmott Creek	0.033	0.040 - 0.070

*Data not available

3.3 Vertical Datum

All FIS reports and FIRMs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared. Until recently, the standard vertical datum used for newly created or revised FIS reports and FIRMs was the National Geodetic Vertical Datum of 1929 (NGVD). With the completion of the North American Vertical Datum of 1988 (NAVD), many FIS reports and FIRMs are now prepared using NAVD as the referenced vertical datum.

Flood elevations shown in this FIS report and on the FIRM are referenced to the NAVD. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. It is important to note that adjacent counties may be referenced to NGVD, which may result in differences in base flood elevations across county lines.

For more information regarding conversion between the NGVD and NAVD, see the FEMA publication entitled *Converting the National Flood Insurance Program to the North American Vertical Datum of 1988* (Reference 6), visit the National Geodetic Survey website at www.ngs.noaa.gov, or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

Temporary vertical monuments are often established during the preparation of a flood hazard analysis for the purpose of establishing local vertical control. Although these monuments are not shown on the FIRM, they may be found in the Technical Support Data Notebook associated with the FIS report and FIRM for this community. Interested individuals may contact FEMA to access these data.

To obtain current elevation, description, and/or location information for benchmarks shown on this map, please contact the Information Services Branch of the NGS at (301) 713-3242, or visit their website at www.ngs.noaa.gov.

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. To assist in this endeavor, each FIS report provides 1-percent-annual-chance floodplain data, which may include a combination of the following: 10-, 2-, 1-, and 0.2-percent-annual-chance flood elevations; delineations of the 1- and 0.2-percent-annual-chance floodplains; and a 1-percent-annual-chance floodway. This information is presented on the FIRM and in many components of the FIS report, including Flood Profiles, Floodway Data tables, and Summary of Stillwater Elevation tables. Users should reference the data presented in the FIS report as well as additional information that may be available at the local community map repository before making flood elevation and/or floodplain boundary determinations.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent-annual-chance flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent-annual-chance flood is employed to indicate additional areas of flood risk in the community. For each stream studied by detailed or limited detailed methods, the 1- and 0.2-percent-annual-chance floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using detailed topographic information from the City of Broken Arrow, and the City of Tulsa (References 35-37).

The 1- and 0.2-percent-annual-chance floodplain boundaries for streams studied by detailed methods are shown on the FIRM. On this map, the 1-percent-annual-chance floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A, AE, and AO), and the 0.2-percent-annual-chance floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 1- and 0.2-percent-annual-chance floodplain boundaries are close together, only the 1-percent-annual-chance floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations, but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

For streams studied by approximate methods, only the 1-percent-annual-chance floodplain boundary is shown on the FIRM (Exhibit 2).

4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 1-percent-annual-chance floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the base flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1 foot, provided that hazardous velocities are not produced. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodways presented in this study were computed for certain stream segments on the basis of equal-conveyance reduction from each side of the floodplain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated for selected cross sections and provided in Table 8, "Floodway Data." The computed floodway is shown on the FIRM (Exhibit 2). In cases where the floodway and 1-percent-annual-chance floodplain boundaries are either close together or collinear, only the floodway boundary is shown on the FIRM.

The area between the floodway and 1-percent-annual-chance floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water surface elevation (WSEL) of the base flood more than 1 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 1.

No floodways were computed for West Bigheart Creek in the City of Sand Springs and for the Split Flow reach in Broken Arrow Creek, City of Broken Arrow, and the ponding area of Wilmott Creek inside the levee at the City of Jenks.

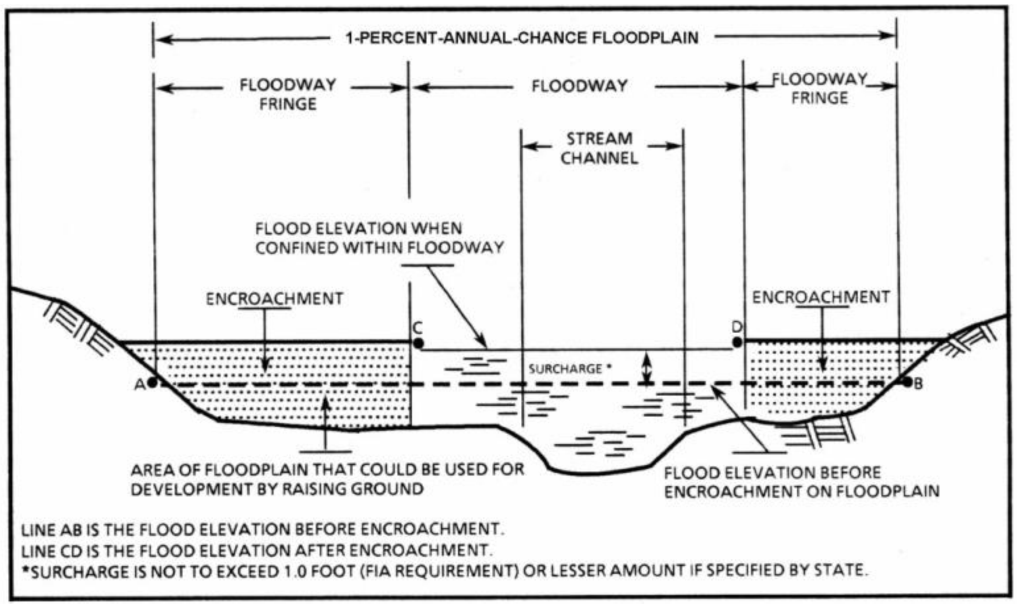

Figure 1. Floodway Schematic

5.0 INSURANCE APPLICATION

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. These zones are as follows:

Zone A

Zone A is the flood insurance rate zone that corresponds to the 1-percent-annual-chance floodplains that are determined in the FIS report by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base (1-percent-annual-chance) flood elevations (BFEs) or depths are shown within this zone.

Zone AE

Zone AE is the flood insurance rate zone that corresponds to the 1-percent-annual-chance floodplains that are determined in the FIS report by detailed methods. Whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AO

Zone AO is the flood insurance rate zone that corresponds to the areas of 1-percent-annual-chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-foot base flood depths derived from the detailed hydraulic analyses are shown within this zone.

Zone X

Zone X is the flood insurance rate zone that corresponds to areas outside the 0.2-percent-annual-chance floodplain, areas within the 0.2-percent-annual-chance floodplain, areas of 1-percent-annual-chance flooding where average depths are less than 1 foot, areas of 1-percent-annual-chance flooding where the contributing drainage area is less than 1 square mile (sq. mi.), and areas protected from the base flood by levees. No BFEs or depths are shown within this zone.

6.0 FLOOD INSURANCE RATE MAP

The FIRM is designed for flood insurance and floodplain management applications. For flood insurance applications, the map designates flood insurance rate zones as described in Section 5.0 and, in the 1-percent-annual-chance floodplains that were studied by detailed methods, shows selected whole-foot BFEs or average depths. Insurance agents use zones and BFEs in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

For floodplain management applications, the map shows by tints, screens, and symbols, the 1- and 0.2-percent-annual-chance floodplains, floodways, and the locations of selected cross sections used in the hydraulic analyses and floodway computations.

The current FIRM presents flooding information for the entire geographic area of Tulsa County. Previously, FIRMs were prepared for each incorporated community and the unincorporated areas of the County identified as flood-prone. This countywide FIRM also includes flood-hazard information that was presented separately on Flood Boundary and Floodway Maps (FBFMs), where applicable. Historical data relating to the maps prepared for each community are presented in Table 5, “Community Map History.”

Table 5: Community Map History

Community Name	Initial Identification Date	Initial FHBM Effective Date	FHBM Revision Date(s)	Initial FIRM Effective Date	FIRM Revision Date(s)
Bixby, City of	06/28/1974	06/28/1974	07/19/1977	09/28/1979	09/12/2024 10/16/2012 08/03/2009 04/16/2003 09/22/1999
Broken Arrow, City of	10/18/1977	10/18/1977	02/26/1980	08/17/1981	09/12/2024 09/30/2016 10/16/2012 04/17/2012 08/03/2009 04/16/2003 09/22/1999 09/05/1984
Collinsville, City of	02/25/1977	02/25/1977	N/A	07/02/1981	10/16/2012 04/03/2012 08/03/2009 09/22/1999
Glenpool, City of	06/28/1974	06/28/1974	06/20/1978 05/28/1976	03/02/1981	10/16/2012 08/03/2009 09/22/1999 04/15/1992
Jenks, City of	01/09/1974	01/09/1974	05/21/1976	02/17/1982	10/16/2012 08/03/2009 09/07/2001 09/22/1999
Lotsee, Village of[1]	09/22/1999	N/A	N/A	09/22/1999	08/03/2009

Table 5: Community Map History, Continued

Community Name	Initial Identification Date	Initial FHBM Effective Date	FHBM Revision Date(s)	Initial FIRM Effective Date	FIRM Revision Date(s)
Owasso, City of	01/04/1974	01/04/1974	08/09/1977 01/14/1977	07/02/1981	10/16/2012 04/03/2012 08/03/2009 04/16/2003 09/22/1999 04/15/1992
Sand Springs, City of	07/26/1974	07/26/1974	04/22/1977	06/15/1981	10/16/2012 08/03/2009 04/02/2008 09/22/1999 07/19/1993
Sapulpa, City of	05/11/1973	05/11/1973	N/A	12/01/1977	10/16/2012 08/03/2009 05/18/2009 09/21/2001 04/26/1983
Skiatook, Town of	06/07/1974	06/07/1974	08/09/1977 06/04/1976	07/16/1980	10/16/2012 08/03/2009 04/02/2008 09/22/1999
Sperry, Town of	12/07/1973	12/07/1973	01/09/1979 06/25/1976	07/16/1981	10/16/2012 08/03/2009 09/22/1999
Tulsa, City of	08/17/1971	N/A	N/A	08/17/1971	09/12/2024 05/02/2019 09/30/2016 10/16/2012 04/17/2012 04/03/2012 08/03/2009 04/02/2008 04/16/2003 09/07/2001 09/22/1999 11/02/1995 11/20/1991 04/16/1991 11/03/1989 02/05/1986 02/01/1985 10/15/1982 08/14/1979 07/30/1976 05/28/1975

Table 5: Community Map History, Continued

Community Name	Initial Identification Date	Initial FHBM Effective Date	FHBM Revision Date(s)	Initial FIRM Effective Date	FIRM Revision Date(s)
Tulsa County, Unincorporated Areas	08/23/1977	08/23/1977	N/A	09/16/1982	09/12/2024 09/30/2016 10/16/2012 08/03/2009 04/16/2003 09/22/1999 03/16/1995 05/04/1992 06/05/1989

[1] No Special Flood Hazard Areas Identified

7.0 OTHER STUDIES

This is a multi-volume FIS. Each volume may be revised separately, in which case it supersedes the previously printed volume. Users should refer to the Table of Contents in Volume 1 for the current effective date of each volume; volumes bearing these dates contain the most up-to-date flood hazard data.

This FIS report either supersedes or is compatible with all previous studies published on streams studied in this report and should be considered authoritative for the purposes of the NFIP.
The USACE published a Special Flood Hazard Information report for Tulsa in October 1970 that showed the 1-percent-annual-chance and Standard Project Flood (the flood that would occur from the most severe combinations of meteorological and hydrologic conditions considered reasonably characteristic of the area) water-surface profiles for nine streams (Reference 38). Those streams are the Arkansas River and Cherry, Flat Rock, Joe, Little Joe, Mingo, Red Fork, South Fork, and Valley View Creeks. The flood information developed for the Special Flood Hazard Information report was based on limited survey data, 10-foot-contour- interval topographic maps, and limited hydrologic and hydraulic data. Because of the more detailed 2-foot-contour-interval topographic data, increases in urbanization, and more detailed hydrologic data, this Flood Insurance Study supersedes the October 1970 report.

A Floodplain Information (FPI) report for Haikey Creek and tributaries was published by the USACE, Tulsa District in September 1973 (Reference 39). The FPI report presented the 1 percent-annual-chance and Standard Project Flood profiles and showed the approximate limits of the flood boundaries. The 1-percent-annual-chance elevations computed for the Flood Insurance Study within the unincorporated areas of Tulsa County on Haikey Creek and its tributaries average approximately 1 to 3 feet higher than those computed for the FPI report. One reason for that increase is the higher discharges caused by a greater amount of urbanization that has occurred in the watershed. Also, better topographic data were available for the Flood Insurance Study, which resulted in a more detailed hydrologic model of the basin. The detailed topographic data allowed the addition of cross sections at numerous points to increase the accuracy of the backwater computations. Channel realignments in several stream reaches have also caused changes in flood elevations.

In December 1976, the USACE, Tulsa District published the Adams Creek and Tributaries FPI report, which addressed the flooding conditions along Adams Creek and its tributaries in Tulsa and Wagoner Counties near Broken Arrow and along the western edge of Tulsa (Reference 33).

An Interim Special Flood Hazard Information report was published by the USACE, Tulsa District in April 1970 for Bird Creek, from the mouth to Sperry (Reference 40). The flood-hazard information was developed to provide guidance for floodplain management on Bird Creek until the Tulsa County FIS was completed. The Bird Creek Special Flood Hazard Information report includes profiles for natural conditions.

A Special Flood Hazard Information report on Polecat and Rock Creeks was prepared by the USACE, Tulsa District in November 1972 (Reference 41).

An FPI report on Polecat Creek was prepared by Mansur, Daubert, Williams, Inc. for the INCOG in June 1976 (Reference 42). That report began at the Okmulgee Expressway and extended upstream.

In December 1977, the USACE, Tulsa District published a report on the May 30, 1976 flood for the Tulsa area (Reference 4). That report presented high-water profiles and flood photographs for many streams in the Tulsa area. Flooded area maps showing approximate flood limits were included in the report. The streams presented in that report included Fred, Haikey, Joe, Little Joe, and Mingo Creeks and Fry Creek No. 2.

The USACE, Tulsa District prepared preliminary reports for the Tulsa Metropolitan Area Urban Study, dated January 1976, for the watersheds studied in the Flood Insurance Study (Reference 43). The reports were prepared to develop plans that, if implemented, could be used to help solve the urban problems associated with water and related land resources.

Previous studies have been done on the Caney River, but the flow estimates have been considerably reduced due to the construction of Hulah and Copan Lakes. The present information on the Caney River supersedes all earlier information.

A local protection project in Skiatook was studied for Bird Creek under Section 205 of the Flood Control Act, approved June 30, 1948 (Public Law 858, 80th Congress, 2nd Session), as amended by Public Law 87-874. A Reconnaissance Report investigating the flooding problems along Bird Creek at Skiatook was prepared by the USACE, Tulsa District, in November 1962 (Reference 44). The project was determined to be economically feasible and a Detailed Project Report (Reference 45) was prepared in May 1966. Because official endorsement of the project by State and local agencies could not be obtained, it was never constructed.

In January 1974, a report entitled "A Study of Flood Solutions for the Bird Creek Basin, Oklahoma" was prepared for the USACE, Tulsa District (Reference 46). Detailed floodplain information was not developed for the above studies.

Detailed studies were performed by the USACE, Tulsa District on Cherry and Red Fork Creeks in West Tulsa for a Detailed Project Report (Reference 47). The report investigated the feasibility of providing flood protection for areas along the streams. The project is designed to protect against a flood equal to the flood of record of September 3, 1940. The September 3, 1940, flood flow of 4,200 cfs (below the confluence of Red Fork Creek) was estimated to be a 4- percent-annual-chance flood. However, 4,200 cfs is now estimated to be between a 10- and 2- percent-annual-chance flood.

The USACE also performed detailed studies for Flat Rock and Valley View Creeks in another Detailed Project Report (Reference 48). The report investigated possible flood-control measures and showed a 1-percent-annual-chance design channel to be economically feasible. The Flat Rock Creek 1-percent-annual-chance flood flow of 11,600 cfs (at Peoria Avenue) in the Detailed Project Report is approximately 25 percent below that shown in this study. This difference is attributed to more refined methods of determining the various flood flows and updated hydrologic data.

In March 1970, the USACE published an FPI report for the main stem of Mingo Creek (Reference 49).

That report showed flows and backwater profiles for the 1-percent-annual- chance flood and Standard Project Flood, as well as photographs of historic and possible future flooding. Mingo Creek 1-percent-annual-chance discharges presented in the report are approximately 55 percent higher than those in this study. The higher discharges, more detailed topographic and historic flood information, and an increase in urbanization in the basin result in the 1-percent-annual-chance profile in this study being an average of approximately 3 feet higher than the 1-percent-annual-chance profile in the USACE report.

This report either supersedes or is compatible with all previous studies published on streams studied in this report and should be considered authoritative for the purposes of the NFIP.

8.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting Federal Insurance and Mitigation Division, FEMA Region VI, Federal Regional Center, Room 206, 800 North Loop 288, Denton, Texas 76201-3698.